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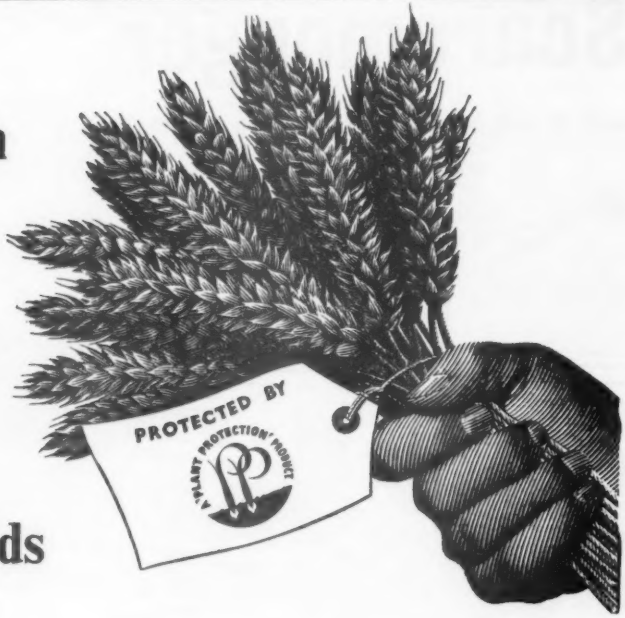

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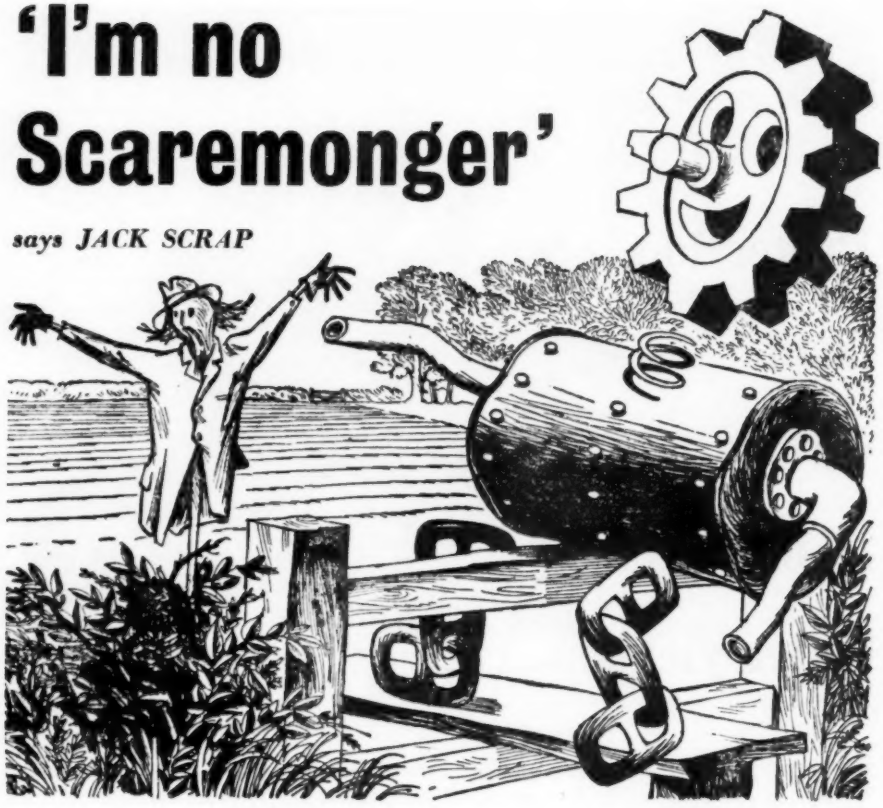

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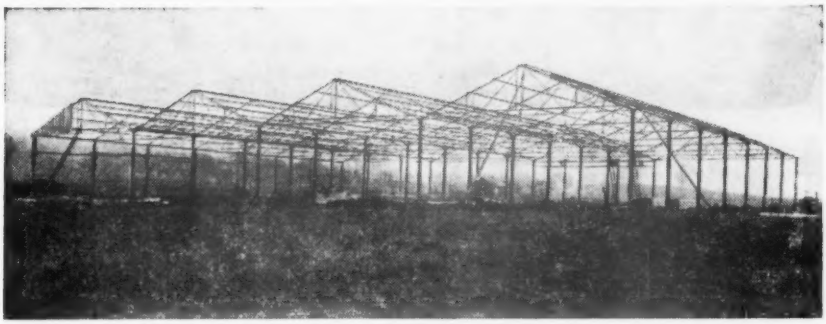

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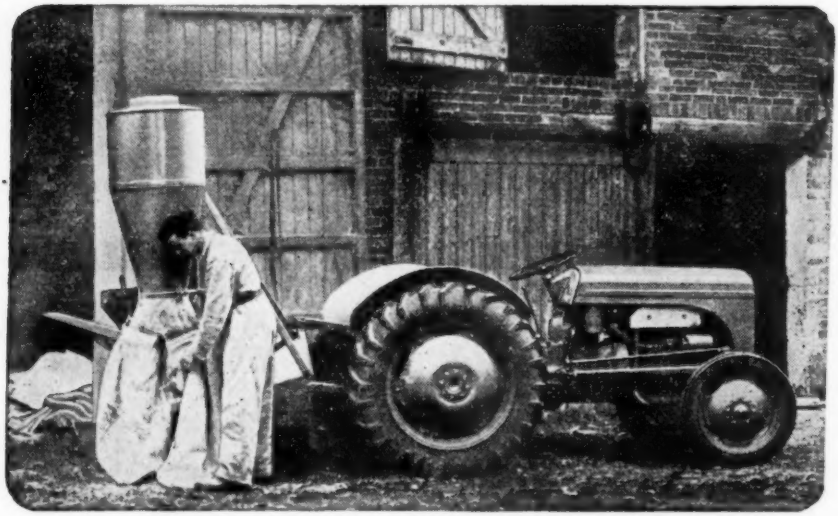

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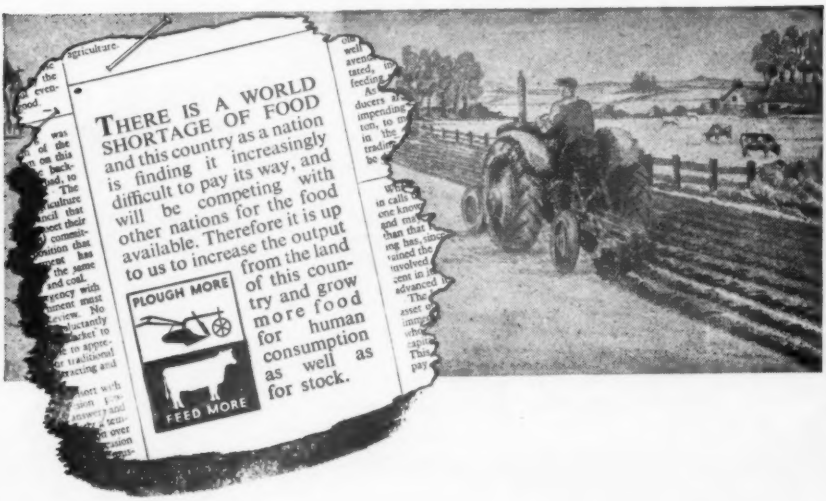
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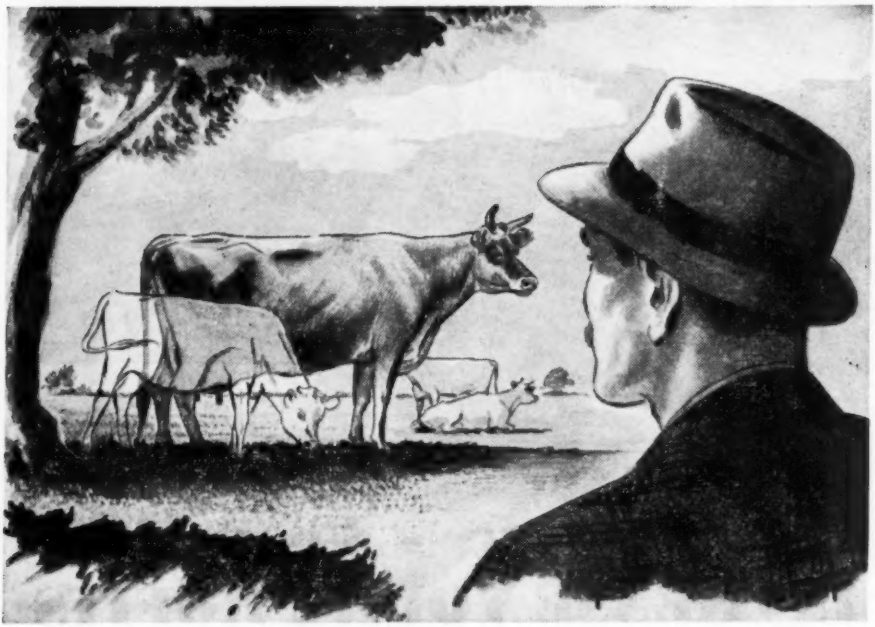

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AGRICULTURE

THE JOURNAL OF THE MINISTRY OF AGRICULTURE

Editorial Offices : 3 Whitehall Place, S.W.1 (*Phone* : *TRAfalgar* 7711)

VOL. LIX No. 5 AUGUST 1952

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MINISTRY OF AGRICULTURE AND FISHERIES

Just published

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Whether you are a landowner or land agent employing your own estate staff to carry out repairs and improvements or a farmer maintaining and repairing your own machinery and implements, you will be interested in this new bulletin prepared by the Agricultural Land Service of the Ministry of Agriculture.

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AGRICULTURE

THE JOURNAL OF THE MINISTRY OF AGRICULTURE

VOL. LIX No. 5 AUGUST 1952

LOOKING AHEAD

J. A. McMILLAN, O.B.E., B.Sc.

The advances made in agricultural techniques and practice during the past ten years have stamped a new pattern of farming on our national economy. Mr. McMillan, Senior Advisory Officer in the National Agricultural Advisory Service, here considers briefly the future trends.

THE change in the pattern of British farming, which first became apparent under the stress of war-time needs, is likely to persist under the economic difficulties with which this country has been beset since 1945. There is still the need for the maximum production of cereals and other human food crops, and at the same time a new emphasis on the growing of coarse grains and other feedingstuffs to support the greatest possible number of stock from our own soil. Greater output per acre, and per man is, and continues to be, the moral charge upon all farmers. Good grass, both permanent and temporary, has come to be recognized as our most important crop, and the outstanding advances made in the production and maintenance of improved swards already demonstrate the potential of their real value in the national agricultural economy.

Though much has been achieved, the future holds fruitful promise of further technical advances in all spheres of husbandry. Let us consider briefly what these may mean in the way of crops, stock, and farm buildings, and how, finally, precept is translated to practice.

Crop Production The origin of a new and outstanding variety probably lies in a selection made ten or more years earlier. Success in plant breeding can be rather elusive and seldom comes without long and patient work. It is not surprising then that the plant breeder wishes to know what are the future needs of the farmer, the grower and the country to aid him in planning his work. To take just one example : white wheats are held to be the most suitable for biscuit making but they are acknowledged to be more difficult to harvest in a catchy season. Is it necessary to plan a long-term breeding programme for better white wheats or can the buyers' requirements be defined more clearly and be met equally well by types less difficult to harvest ?

There are a number of lines in which the plant breeder can direct his work with more confidence. Our acres are strictly limited and there is a continuing need to produce varieties capable of giving higher yields. The cereal varieties of the future are likely to be stiff in the straw, capable of responding to liberal fertilizer treatment without lodging, and to be suitable for combine harvesting. Earliness for the later districts and resistance to pest and disease attack are also features that will become of greater importance with the increase in the tillage acreage and the drive for intensive production.

The earlier work in the breeding of new strains of grasses and clovers was related mainly to the quality of persistency. Now, the short-term ley has attained a new importance and we seek by intensive management to get more and longer grazing and a greater weight of conserved products for winter use. Certain characteristics of grasses and clovers, such as leafiness, period of maximum growth, response to fertilizers and recovery after defoliation, have assumed a higher value. Already strains are in use that fit into a short-term system of intensive management, and a stimulus has been given to the breeding of high-yielding sorts to suit our variable soils and climatic conditions.

Few question the value of the short-term ley in increasing soil fertility, but so far we have no great weight of experimental evidence to support this view. Experiments on the ley as a fertility builder are in progress, and there is need for much more detailed work on the rooting habits of various species of grasses and clovers. The plant breeder who would anticipate our further needs should think not only of productivity above ground but of the influence of various rooting systems on soil fertility. This type of study may even have a bearing on the solution of an obscure problem such as the control of potato root eelworm.

Interesting possibilities are opening up through the ability to duplicate the chromosome numbers by the use of colchicine. The plant breeder is already sensing the possible value of this newer technique in his endeavour to produce good cropping potato varieties immune to blight, and sugar beet of higher sugar content.

Rapid advances are being made in methods of weed control, and change after change in practice is being made as first one and then another treatment proves more effective. The use of growth-regulating substances is extending and new products are continuously on test. Useful knowledge is being built up on the differing susceptibility of varieties and the effects of spraying at various stages in plant growth. The need for materials of greater selectivity, particularly for use in crops such as peas and lucerne, is recognized, and interesting developments lie ahead in the improvement of pre-emergence sprays for use on root crops expensive to weed by hand. Fortunately, there is no disposition to regard chemical weed control as an alternative to "clean" farming.

Though good progress has been made in farm mechanization during recent years, there is still a place for the development of labour-saving machines and equipment. A moderately priced general-purpose harvester suitable for potatoes, sugar beet and fodder roots would be in keen demand ; modifications of the combine drill are sure to be necessary as we learn more of the value of fertilizer placement for different crops ; suitable mechanical equipment for the thinning of row crops would do much to iron out the high labour peaks of early summer. There also seems a promising line for further study in the adaptation and use of the electric and other easily movable fences for strip grazing and in the production of efficient forage harvesters to assist in the conservation of grass and other green crops.

Livestock Production As far ahead as we dare speculate, there appears a need to produce more meat and to maintain our milk output, largely from home-grown foods. Advances in livestock husbandry are likely to lie in the breeding of better stock, increasing prolificacy, the speeding up of the breeding cycle and the more efficient conversion of vegetable foods to animal products.

In breeding, perhaps we have been too inclined to rest on the reputation for British livestock built up by our forebears. Milk recording as a measure of a cow's performance has only lately been taken up widely ; little has been done to record the performance of our beef cattle ; pig recording and litter testing have not yet made a serious contribution to the improvement of our commercial pigs.

Artificial insemination is becoming an important aid to the improvement of our cattle. There are possibilities too in breeding an increasing number of stock from our best animals by stimulating egg formation at an early age and implanting fertilized eggs in less valuable stock for development. At present such an advance is rather speculative, but suitable techniques may shortly be available.

Beef, milk and mutton in future will require to be produced largely from bulky home-grown foods. Will it be desirable to breed cattle more capable of using bulk than those bred and reared mainly on imported concentrates ? Is rumen inoculation likely to assist a calf to develop a suitable rumen flora and to enable it to grow, thrive and build up a digestive system more capable of dealing with bulky foods ? What is the loss of efficiency in food conversion through disease, parasitic worms and unsuitable housing ? Have food accessories a place in more efficient food conversion, and, if so, under what conditions ? These and many more kindred questions await study, and indeed must be solved if we wish to minimize the loss of the large volume of concentrated feedingstuffs which was imported in pre-war years.

Farm Buildings and Land Tenure

Many of our farm buildings are over a hundred years old, and though built substantially, show the need for major repairs. They were erected when labour and materials were relatively cheap and there seemed little prospect of drastic changes in practice or in the application of mechanical power to farming. High building costs and the many advantages of adaptable buildings are tending to lead to a simplification of design and to a decision to build for a life of about twenty-five years. Adaptations of old buildings in sound structural condition are still being made to provide cover for grain drying, machinery storage and cattle yards and, as electrical power becomes more widely available in rural areas, it is being used for various barn operations. Yet there are many farms where a new and simple layout proves to be less costly than substantial alterations to existing buildings and new steadings are appearing here and there, particularly in the traditional arable areas.

Agriculture in England and Wales has grown slowly through the centuries from a means of subsistence to an industry, and that development has been accompanied by changes in systems of land tenure. Recent trends have been towards an increase in the number of owner-occupiers and for farm units to become smaller through a variety of causes such as inheritance, the sale of estates to pay death duties and the development of intensive culture in a few favoured districts. The average agricultural holding is well under 100 acres, and in most counties 60 per cent of all occupiers farm between 1 and 50 acres. Further subdivision seems improbable. Indeed there is a prospect of some amalgamation of holdings, particularly in certain industrial and poor land areas, but a number of owner-occupiers of small and uneconomic units, when judged by normal standards, are likely to survive. They are farmed by men with independent ideas—men who maintain that by working hard and for long hours they can compete with their better organized and equipped neighbours on larger holdings. The evidence points, however, to the gradual decrease in the number of holdings

in spite of the real land hunger which is now apparent. Indeed one problem of the future is how to introduce new blood into farming.

Practice with Science Few now dispute the value of agricultural science, but there are conflicting views as to how far practice should be guided by science. The broader interest in the importance of our agriculture created by the war and subsequent shortages has led to a re-examination of the need for research and the means of passing it to the farmer. We would do well to remember that the former balance has been upset by the heavy drop in the volume of imported feedingstuffs and the consequent loss of protein and minerals for the feeding of livestock and of their residual values for restoring soil fertility. This is but one of the many new problems that are pointing to new lines of research.

Fortunately, there are now an increasing number of farmers and growers, quite a proportion with a university or college training, who are helping the advisory services to translate the new findings of research into practice by example on their own farms and by advice given on the public platform. The number of farm institutes, too, has been increased, and so each year more are learning the "why" as well as the "how" of farming operations.

In future much more attention is certain to be given to farm management studies in teaching and advisory work. New practices have sometimes been introduced without a true appreciation of their effect on the organization of farm labour or on the economy of the farm as a whole. The National Agricultural Advisory Service of late has received an increasing number of inquiries on farm management problems, and it has become clear that careful thought will have to be given to the training of its staff to meet this new demand. It is of interest to note that already there has been a small interchange of staff with those engaged in farm efficiency studies in America. It is believed this co-operation will be mutually helpful and will provide useful guidance for the future training of our younger officers.

The Tasks Ahead To sum up, what of the tasks ahead? There is little hope of expanding our agricultural land, though the improvement of the better marginal land under the provisions of the Livestock Rearing Act, 1951, can assist in increasing the numbers of store cattle and sheep. Even including the poorer land, however, the area per head of the population is little over half an acre, and agriculture is one of many industries competing with labour.

There is a clear call for high output both per acre and per man. We compare unfavourably with certain Continental countries such as Belgium, Denmark and Holland in output per acre, but greatly exceed these countries in output per man, though still far short of the man-output of America. We should give thought to the possibilities of increasing output per man, a side of production rather overlooked during the all-out effort of the war years.

Whatever the future holds, there will be wide variations in our farming systems due to differences of soil, climate, size and layout of holding. The annual rainfall alone can vary from under 22 to over 100 inches and so exerts a major influence on the best system of farming for a particular district. There will always be a place for the expression of initiative. The farmer with an eye for a beast, the hill sheep enthusiast and the born applied mechanic will each give of their best if allowed to follow their natural bents. Throughout the history of our agriculture such men have been the pioneers in agriculture and the mainsprings of true progress.

THE ECONOMY OF AN INTENSIVE DAIRY FARM

C. H. BLAGBURN, B.Sc.(Agric.), N.D.A.
Department of Agricultural Economics, Reading University
and
R. S. BOYER, N.D.A.
National Agricultural Advisory Service, South-Eastern Province

The system of management described in this article clearly shows how, by carefully planning the production and use of feedingstuffs, together with a high rate of stocking, the output and profit of the average small dairy farm can be substantially increased.

THE economic advantages to be gained, especially on the small farm, by aiming at the maximum density of stocking and the highest possible output per acre, are well illustrated by the financial results obtained on a 130-acre dairy farm in the south of England during the past two years. The farm in question does not enjoy any special natural advantages, nor is the quality of the livestock outstandingly high. Yet in 1949-50 it succeeded in reaching a total production of over £42 per acre, and this figure was raised to over £48 an acre in the following year, compared with a normal production of about £24 an acre for dairy farms of this size in the same region. Profits in these two years were approximately £12 and £18 an acre respectively.

Apart from a few pigs, the farming system is concentrated almost solely on dairying, and about 85 per cent of the total income is derived from milk. The whole aim and object of the cropping system is therefore to provide food for the dairy herd.

The cattle consist of Dairy Shorthorns in two herds, a larger one comprising thirty-three T.T. attested cows, and the other, twenty-two accredited animals. Both herds are grading up to pedigree, and the next crop of calves will be "D" progeny. The attested herd is machine-milked and will be expanded as the attested in-calf heifers join the herd. The accredited herd is hand-milked and will be reduced as the attested herd expands. Milk yields are of the order of 700–800 gallons per cow. There are two ranges of buildings (both of the orthodox cowshed type) but those for the accredited stock would need considerable modifications to bring them up to T.T. standard. To maintain existing herd numbers, the range of buildings for attested stock will have to be extended. Mains water is supplied to practically all the fields ; the remainder will be connected during this year.

Of the 130 acres, about 30 are tillage and 100 grass. Some permanent pasture is maintained as home paddocks and a small acreage is wet, unploughable land, but the greater proportion of the grass is under leys. The soil is light to medium loam over plateau gravel, and like much of the land in southern England, is very prone to dry out during the summer months.

Providing the Feedingstuffs The aim of the farm is the production of winter milk, and as much food as possible is home-grown. With the high density of stocking, the rotation must be flexible to achieve this end. One of the greatest problems is to prevent over-grazing of the leys, especially in a dry summer, and although three- to four-year leys are the basis, a ley may be ploughed after two years if the productivity falls. The basic rotation is corn—roots—corn—3–4 years ley, or roots—corn—3–4 years ley.

The grazing system followed until recently was to graze cattle rotationally in 4-acre paddocks of a Cockle Park type mixture. During 1951, strip grazing was introduced, with a consequent saving in the acreage required for the dairy cows. Twenty-six cows were turned into a 3-acre paddock on April 16, 1951, and strip-grazed until May 2, 1951—a total of 17 days. Concentrate feeding was dropped on the third day, and milk yield rose steadily to a peak increase of 10 gallons per day. The basal fertilizer dressing was 3 cwt. National Compound Fertilizer Type 9 and 1¼ cwt. sulphate of ammonia, applied in March. After the grazing, a further 2 cwt. sulphate of ammonia were applied, and a cut of 2¼ tons per acre of hay was taken in late June. In all, this herd was carried on 11 acres for grazing during 1951.

Fertilizer policy has been to apply 1¼ cwt. sulphate of ammonia and 3 cwt. superphosphate per acre to all grass. A recent soil analysis by the N.A.A.S. has established a deficiency of potash, and, in future, 3 cwt. National Compound Fertilizer Type 1A per acre will be used. Corn crops rarely receive fertilizers. A ley due to be broken up is dunged heavily and ploughed in. This may take place after a hay cut in late May to early June, and the field is then sown to roots.

Kale, mangolds, swedes, and soft turnips if a kale crop fails, have been the source of green food during the winter. Oats and barley are frequently grown separately, so that in a good year some barley may be sold for cash. Average corn yields per acre are : dredge, 14 sacks ; barley, 14 sacks ; oats, 16–18 sacks (with a maximum yield of 24 sacks). Hay yields average 3 tons per acre. Thus in 1951, 35 acres were cut for hay and yielded 107 tons.

Winter rations for the dairy cows are 10–12 lb. hay, 35–40 lb. roots, and 3½ lb. concentrates for each gallon after the first. Oat straw is fed *ad lib*, at night in the field.

The concentrate mixture varies, but a typical one is :

	cwt.
Fishmeal	1
Linseed cake	2
Flaked maize	2
Crushed oats	5
No. 1 Dairy nuts	4–5

The permanent labour force consists of four men and two young boys. Machinery is not elaborate, comprising one medium tractor with ploughing, cultivating and sowing implements, a mowing machine and a binder. Two horses are kept to do the lighter cultivations and carting, and especially for taking fodder to the cattle.

High Output per Acre As has already been mentioned, the outstanding feature of the farm is the high density of stocking. Measured in "livestock units",* 67.4 units were carried per 100 acres of land in 1950–51, compared with a normal figure of around 34 units for this size of dairy farm. An essential factor in maintaining such a high level of stocking has obviously been the effective use of the available land, by the methods described above, to provide a high output of food for cows. Another factor is the careful rationing of feedingstuffs in relation to individual cow yields. One method of assessing the efficiency of utilization of livestock

* A livestock unit, for this purpose, is the equivalent of a dairy cow, other stock being converted at appropriate rates based on normal food requirements.

feed and of land used for producing it, is to calculate the total acreage of crops and grass occupied per unit of stock, making an allowance for bought food at the rate of an additional acre for every ton of concentrates bought. A normal figure for dairy farms in the region concerned is from 2¾ to 3 acres per livestock unit. On this farm, however, the figure is only 2 acres per livestock unit.

Considerable thought is being given to the management of grassland to reduce still further this 2 acres of feed per stock unit. Strip grazing has shown considerable saving in this direction. Silage-making will be introduced to make use of the grass saved and to reduce haymaking. Simple ley mixtures are being introduced to fit in with this policy and to eliminate, or at least narrow, the "burnt up" period in the summer. This policy will not give full results until 1954, since it can only be introduced slowly because of the very heavy stocking. Grassland recording is being started during the coming year to find out which fields are producing at a high level, and whether any particular mixture is worthy of a more important place.

A larger acreage of kale is being grown and will be strip-grazed with the aid of an electric fence during the coming winter. It is expected that these improvements will also help to cut down the bill for purchased feed. The aim is to provide maintenance and two gallons of milk from roughages instead of the present maintenance and one gallon. Some reduction in labour should also be possible when one dairy only is milked and silage has replaced the hand-hoed roots.

Another factor that has contributed towards the high income on this farm is the comparatively low ratio of young stock to mature animals in the herd. On the small farm, where maximum turnover is all-important, it is bad policy from the economic point of view to devote too much of the limited area available to the rearing of young stock, since this would inevitably mean a low return per acre. Nevertheless on dairy farms in general the number of stock carried is often equal to, and not infrequently more than that of the dairy herd. This must mean either that there are surplus heifers to sell or that there is a high rate of replacement of cows in the herd. On the farm under consideration, 33 followers suffice to maintain replacements for a herd of 55 cows. The result is seen in that although the average milk sales of £90 per cow on this farm were if anything a little below normal, the income per unit of all stock averaged nearly £67, compared with a normal figure of about £54.

The net result of the efficient use of land for carrying the maximum number of directly productive stock is that every acre used for growing stock food on this farm earned an income of £33, as against an average figure of about £18 per acre for dairy farms of similar size.

Costs in Relation to Output The heavy stocking policy on this farm has made it necessary to supplement home-grown fodder with fairly heavy purchases of concentrates. The total feed bill in 1950–51 was nearly £1,300, i.e., over £9 an acre—or just about double the average cost incurred on dairy farms. There is little doubt, however, that this policy has paid the farmer ; nor is it contrary to the national objective of increased self-sufficiency in feedingstuffs. Nationally, the aim is not to do without purchased feedingstuffs altogether, but to use the limited amount available to the best advantage for supplementing home-grown fodder. The amount of *purchased* food fed per gallon of milk on this farm—about 2⅛ lb. is, it is true, a little above the average of 2 lb. per gallon found on dairy farms costed by Reading University in the south of England. But the *total*

concentrates fed, including home-grown, did not exceed 2¼ lb. per gallon, compared with an average on the other farms of 3¼ lb. ; and the net contribution to national food supplies, after deducting the high cost of purchased foods, was still, at £38 10s. per acre, more than double the normal net output of about £18 for dairy farms. Moreover, as is shown below, one effect of the high turnover was that this output was attained at an exceptionally low cost. The following tables show the costs incurred in the two years under consideration, compared with the average for forty-six dairy farms of 100–250 acres in the region. These costs are shown both per 100 acres of the farm and per £100 of net output.

Table 1

Costs Incurred per 100 Acres*

	130-Acre Dairy Farm		Average of 46 Dairy Farms of 100-250 Acres
	1949-50	1950-51	
	£	£	£
Rent and Rates	221	221	150
Fertilizers	58	95	87
Labour	1,250	1,220	807
Power and machinery costs†	286	336	378
Other expenses	279	200	155
Total	**£2,094**	**£2,072**	**£1,577**

Table 2

Costs Incurred per £100 Net Output*

	130-Acre Dairy Farm		Average of 46 Dairy Farms of 100-250 Acres
	1949-50	1950-51	
	£ *s.*	£ *s.*	£ *s.*
Rent and rates	6 14	5 10	8 6
Fertilizers	1 16	2 10	4 16
Labour	37 18	31 14	44 12
Power and machinery costs†	8 14	8 14	20 18
Other expenses	8 8	5 4	8 10
Total	**£63 10**	**£53 12**	**£87 2**

† Fuel, repairs, depreciation, electricity and machinery hire.

On a farm of such high output it is not surprising that costs incurred, on an acreage basis, are well above the average : in such circumstances, however, costs per acre are completely meaningless. The point of real significance is that whereas the average dairy farm of this size spent over £87 on labour, machine power, fertilizers, rent, etc., for every £100-worth of food produced, this farm in 1949–50 spent only £63 10s. and reduced this figure by about £10 in 1950–51 (although, in fact, actual expenditure was just about the same in both years). This represents an exceptionally economical use of valuable national resources, as well as giving the farmer himself a very comfortable profit.

A High Turnover The results obtained are a good illustration of the effect of "spreading the overheads" by high turnover. By using purchased feedingstuffs in addition to home-grown forage to maintain

* In this article, output and cost figures for the year 1949–50 have been adjusted to the level of prices, wages, etc., ruling in 1950–51 : differences between the two years, therefore, do not reflect price and cost movements.

maximum cow numbers, turnover has been greatly expanded without any material increase in " overhead" charges, such as rent, rates and machinery-operating costs. Even the wage bill has risen far less in proportion than has the output. By spreading these costs over a big turnover, the percentage margin of profit on turnover is considerably increased, while the profit per acre goes up still more rapidly.

The high turnover achieved has depended largely on a judicious combination of home-grown and purchased feedingstuffs. If the farmer had attempted to cut his food bill to more normal proportions, it could have been done, in present circumstances, only by reducing the size of his herd, and with it his output per acre. But his other costs—apart from some possible reduction in labour—would have remained largely unchanged and, in consequence, total profit would undoubtedly have fallen considerably. As cropping and grassland management improve it will no doubt be possible to replace a part of the present expensive purchased feed with cheaper home-grown fodder, and so benefit the economy of the farm still further. In the event of a rise in the prices of purchased concentrates this would be all the more necessary. But though some saving may be effected, it is unlikely that it would ever be possible to maintain the present high level of productivity and profit on this farm without considerable reliance on purchased feed.

THE RECLAMATION OF THE WASH

J. C. WALLACE

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The Zuyder Zee has been reclaimed from the sea and is now producing food. Why not reclaim the Wash ? The idea has been discussed at intervals in the press and elsewhere for well over thirty years, and relatively small-scale enclosures have, in fact, been made. But, as Mr. Wallace points out, the process of reclamation is both difficult and costly.

MAN in his effort to produce food throughout the ages has destroyed much land. This destruction still goes on, and much good land is nowadays being used for other purposes. Until recent times, it has been possible to find new areas easily capable of cultivation, but this has now come to an end, and the world as a whole, and especially we in this country, are faced with a difficult problem. No doubt means will be found to bring under control large tracts of land at present not suitable for cultivation, as for instance in tropical countries, but in view of modern political and economic tendencies, this country may not readily benefit.

The problem of getting more land for food production has been a pertinent one in the Netherlands for many generations, and the Dutch have to some extent overcome the difficulty by reclaiming land from the sea. Continuous reclamation is going on along the Dutch coasts, and the most striking of this work is the enclosure and reclamation of the Zuyder Zee. The Germans have also carried out considerable reclamation along their north-west coast, and the Italians have won back large areas of the low-lying Pontine marshes.

THE RECLAMATION OF THE WASH

In this country, however, although we have a long coastline, the area of possible reclamation from the sea is limited, and the only really important area worth considering is the Wash. It may be said at once that for reasons which will be explained later, wholesale reclamation of the Wash, as was done in the Zuyder Zee, is not practicable. It may also be said that piecemeal reclamation of the Wash has been going on for over two thousand years, and is still going on. But this kind of reclamation is a slow process, and unless it can be greatly hastened will not be of much assistance in alleviating the present scarcity of food.

Two Thousand Years' Work The whole of the Holland Division of Lincolnshire, part of Kesteven, part of north-west Norfolk, and most of the Isle of Ely, consists of reclaimed land. When the Romans came to Britain, the whole of this area was a vast morass, with long arms of the sea running far inland ; a considerable part of it was continuously inundated by the sea, or flooded by the waters of the great rivers which flowed into it. Where these rivers met the open sea, large areas of alluvium had been deposited.

To keep out the sea, the Romans enclosed the whole area by building an embankment or sea-wall round the Wash from a point near Skegness in the north to another near King's Lynn in the south. They then confined the rivers into narrow channels and constructed a system of internal open drains. In this way they were able to bring much of the alluvial land under cultivation, and the food produced from it not only fed their armies in Britain but their legions in northern Europe. It is recorded that they had as many as 250 ships transporting food from the Wash to northern Germany.

After the building of the Roman Bank, further accretion took place, chiefly at the head of the bay, but it was not until the middle of the seventeenth century that the enclosure was extended, and another bank was built to take in about 17,000 acres. Since then, numerous small enclosures have been made, the most recent being in 1918, 1919, 1949, and 1951.

Proposals for Large-Scale Reclamation The alluvium enclosed by the Roman Bank had been steadily growing for many thousands of years. Fresh accretion has also taken place outside the bank, and this happens as each succeeding bank is built. The process is, however, a very gradual one along the northern side of the Wash, and even though it is more rapid at the head of the bay, it is still extremely slow.

The idea of encouraging quicker accretion was first mooted in the middle of the seventeenth century. In 1662, Vermuyden, the Dutch engineer, suggested joining the rivers Nene and Welland, and taking them in a single channel into the Wash in the hope of encouraging more rapid accretion. In 1751, Nathaniel Kindersley, a noted drainage engineer, put forward a large-scale scheme which he considered would bring about the rapid wholesale silting up of the Wash, enable nearly a million acres to be cultivated, and a new road to be constructed from Boston to King's Lynn. He proposed to take the Nene by a new cut into the Ouse at King's Lynn and to join the Welland to the Witham near Boston, taking the combined rivers by a new cut to the sea near Wainfleet. Thus he proposed to redirect the four rivers right out to the mouth of the bay.

Nothing came of this proposal, but more than eighty years later—in 1837—a number of landlords and other interested bodies invited Sir John

Rennie to make a survey and to report on the possible large-scale reclamation of the Wash.

Rennie suggested that the channels of the four rivers, the Ouse, Nene, Welland and Witham, should be confined by fascine work, and led to one common outfall in the centre of the Wash. He estimated that the new land thus obtained would be 150,000 acres, which, in a few years, would be worth £40 per acre—a total of £6 million. The cost of reclamation he estimated at £2 million, leaving a profit of £4 million. His report was submitted to a meeting in London in 1839. The meeting " expressed the desirability of the work" and resolved "that the execution of the same must necessarily exceed the means of private individuals and ought therefore to receive the grave consideration of Her Majesty's Government as a purely national object." But nothing was done.

Future Possibilities It is clear, in the light of modern knowledge, that wholesale reclamation of the Wash on similar lines to that of the Zuyder Zee is not practicable—for two main reasons : first, the rise and fall of the tides in the Zuyder Zee is only a few feet compared with 20 feet and more in the Wash ; secondly, when proper precautions are taken the sea-bed of a great part of the Zuyder Zee is capable of almost immediate cultivation, whereas that of the Wash consists mostly of raw, fine silt and sand.

At the present time only comparatively narrow stretches along the shores of the Wash are ready to be reclaimed. The recent enclosure at Wingland (1951) has been made only thirty years after the previous one in that area. The accretion here has been quicker than in any previous operation of this kind, and this is probably due in part to the effect of the previous (1918) bank on the flow of the tides, but chiefly to the rapid spread of rice grass (*Spartina Townsendii*).

Spartina was planted by the writer at Frampton Marsh in the late 1920s. Because of the rapid flow of the tides in the large creeks on those marshes, it has not developed to any great extent, but it has been washed down on to the mud flats near the outfall of the Witham and is spreading slowly on them. It has also spread to the north of the Witham outfall, where plantings have also been made by H.M. Prison Commissioners, who own the frontage there. So far as is known there are no records of the planting of *Spartina* on the Wingland and Terrington marshes, although this grass now covers nearly 600 acres in that area. *Spartina* was, however, planted on the north Norfolk coast about the same time as that at Frampton, and it may have spread from both these places to Wingland and Terrington. In view of the flow of the tides, it is more likely to have come from the Frampton marshes.

The speed at which reclamation can be carried out is, of course, governed by the rate of accretion and, as has already been mentioned, this varies at different parts of the coast. The rate has been quickest at the head of the bay, between the rivers Welland and Ouse. The area enclosed by the 1660 reclamation is about four miles wide at its widest part, and took over 1,500 years to accrete. Subsequent reclamations on a much smaller scale have taken in alluvium which has been deposited over the course of fifty to eighty years. On the north coast of the Wash, accretion has been very slow. There is only one new bank here, erected about 1850. It is less than half a mile from the old Roman Bank, and this narrow strip took nearly 1,800 years to form. At Frieston the Roman Bank is still the main sea-bank and the deposit of alluvium here is only about 400 yards wide.

Now it is obvious that the wider the strip which can be reclaimed at one time, the lower is the cost of reclamation per acre. But whereas accretion takes place rapidly for some years outside a new bank, it then slows down, and after about half a mile, becomes very slow indeed. The frequent building of new banks is slow and expensive, and there is the problem of the nature of the soil which is recovered. The first alluvium deposited along the new bank is of a light sandy nature, but subsequently the deposit on the top of this becomes of a more clayey and heavy character, as shown by the heavy character of the areas recently reclaimed at Holbeach Marsh and Wingland.

Two questions therefore arise : first, is it possible by the proper siting of new banks or by the creation of groyns coupled with the use of *Spartina* to encourage rapid accretion; and, secondly, it is possible in any way to control the nature of the deposit so as to get a more amenable mixture of soil than is at present being deposited?

The difficulty in the way of further reclamation is, of course, that of cost. The saltings or outmarsh outside the bank is the property of the riparian owner, i.e., the owner of the land immediately inside the bank, and is under his control as far as mean high tide level. Of the numerous frontagers or riparian owners, only a few of the larger farmers are able and willing to put down the necessary capital. The cost of erecting a new bank alone is at least £9,000 per mile. In addition, there are sluices to erect for drainage purposes, there are ditches to dig and drains to lay, roads to make and, in some cases, several years to wait before the new land can be ploughed. It is not surprising then that, faced with these high expenses, a number of the riparian owners who graze the saltings are content to continue using the land in this way.

Despite these difficulties, however, it should be recorded that since the end of the war nearly half the land that is ripe for reclamation has, in fact, been reclaimed by private interests.

It appears that because of the large amount of capital involved, and other difficulties, reclamation by private interests has nearly come to an end, at least, for the time being.

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BIRD MIGRATION AND FOOT-AND-MOUTH DISEASE

The article on this subject on pp. 213–228 has been reprinted in pamphlet form and is available from H.M. Stationery Office. Price 4d. net (by post, 5d.)

BIRD MIGRATION AND FOOT-AND-MOUTH DISEASE

W. W. WILSON, M.R.C.V.S. and R. C. MATHESON, M.R.C.V.S.
Ministry of Agriculture and Fisheries

Are migratory birds to blame for the introduction of foot-and-mouth disease into this country? If so, which birds are involved and what is the extent of their responsibility? In this article the writers examine the evidence at present available on the subject.

THE series of outbreaks of foot-and-mouth disease in the autumn of 1951 in the eastern counties of England gave rise to considerable speculation on the method by which infection was introduced into the country. There is a widely held opinion among laymen and veterinarians alike that the invasion was airborne and, in fact, introduced by migratory birds. The bird transmission theory is not original; it has been the subject of intermittent consideration for about thirty years. It is a theory obviously incapable of positive proof under the ordinary conditions of stock husbandry, so that any conclusions as to its validity must be based on the sum of circumstantial evidence. The purpose of this article is to examine the merits of the evidence at our disposal.

ORIGINS OF PREVIOUS BRITISH INFECTIONS

It is first necessary to consider the various methods by which disease is thought to have been introduced into this country in the past and to what extent they have a bearing on present-day infections.

Importation of Live Animals. The earliest agreed record of foot-and-mouth disease in this country is for 1839, when there was a very widespread epidemic. In those days and for some fifty years after, there was a constant interchange of livestock between Britain and the Continent which resulted in frequent waves of disease sweeping across this country until the order of 1892 put an end to the trade. A considerable import trade from the Argentine came to an end by Order following the introduction of disease into that country in 1899. The North American trade which was extinguished on commercial grounds at the beginning of the first World War, and revived for a short period in the late 'twenties, has not since been resumed. We have, of course, during all that period, imported large numbers of stock from Ireland and continue to accept animals from there when available. This trade and occasional importations of pedigree stock from other countries continues, but only under conditions which would render the chance of introducing disease remote.

Importation of Animal Carcasses. When livestock ceased to be imported from the Continent, a large business in freshly-killed meat developed. After various attempts at control, this trade was suppressed by the Importation of Carcasses (Prohibition) Order of 1926, and the risk from this source was finally eliminated. With the development of refrigeration early in the present century, it became possible to import increasing quantities of chilled meat from other continents. The risk of introducing disease in this way was not appreciated until the work of the Foot-and-Mouth Disease Research Committee in 1926(1) established that the virus could survive for as long as 2½ months in chilled meat carcasses. This resulted in the Boiling of Animal Foodstuffs and the Meat Wrapping Materials Orders, which have gone a considerable way towards controlling the dangers from imported meat. However, the fact that almost three-fifths of all initial outbreaks of disease in the last twelve years have been in swine, and almost invariably in swine

fed on swill or having access to suspect material, indicates that the danger from this source is ever present and a factor to be continually borne in mind when inquiring into the origins of confirmed cases.

Animal Feedingstuffs. Early in the century imported feedingstuffs were held to be responsible for occasional outbreaks. Concentrated foods, especially the various high protein cakes, are manufactured by methods which eliminate the possibility of virus survival. Hay and straw are imported in varying quantities according to season, but only from countries free from disease. It is considered that there is no longer any risk of infection being introduced in this way.

Packing Materials. A large proportion of our imports of manufactured goods arrive packed in hay or straw, the further use of which is governed by the Packing Materials Order of 1925. Reports on outbreaks indicate the possibility of infection being conveyed by other materials as, for example, in the packing of Dutch bulbs and on fresh horticultural produce. These and other contacts with imported material are now regarded as minor risks.

Biological Products. An isolated outbreak of disease in Gloucester in 1938 was proved to originate from treatment with an infected glandular product of foreign origin. The use of these preparations is now controlled by the Serum and Glandular Products Order of 1939.

Movements of Persons and Vehicles from Abroad. There is no evidence of infection having been conveyed in this way and the possibility is thought to be remote.

ORIGINS OF PRESENT-DAY INFECTIONS

From what has been said it seems likely that the only continuing major risk to our livestock is from imported animal carcasses. Perusal of case histories in primary pig outbreaks shows, with almost monotonous regularity, reports of " pigs fed on swill," " pigs had access to foreign bones," " owner is a butcher," or variations of the same theme. With rare exceptions primary pig outbreaks occur in housed animals, and it is difficult to appreciate what other means there could be of introducing infection to stock kept under enclosed conditions. Reports on a number of primary cases in cattle also indicate the possibility of contact with swill or other infective material.

Our present Head Office case records date from the reorganization of the Animal Health Division on April 1, 1938, and they show that between that date and October 31, 1950, there were 365 primary outbreaks of foot-and-mouth disease in Great Britain. Of these, 223 or three-fifths of the total, occurred in pigs, 134 in cattle and 8 in sheep. For the purposes of further comparison, it is proposed to treat the primary cattle and sheep cases as one entity of 142. Careful study of case histories showed that the possibility of contact with swill or other imported material could not be excluded in 50 of these cases, leaving some 92 cases of undetermined origin. Further breakdown of the figures indicated a definite concentration of primary outbreaks in the eight coastal counties from Lincolnshire to Dorsetshire, with 49 of the 92 primary outbreaks of unknown origin occurring in this group. Details of these totals are given in Table 1.

The eight coastal counties contain rather less than one-seventh of the total livestock of the country yet, as will be seen from Table 1, the total number of outbreaks of obscure origin among cattle and sheep in this area was greater than for the remainder of the country. It cannot be maintained that the average concentration of population or industry or of livestock is substantially greater in these counties than in other areas of the country, or

that any of the previously enumerated factors are especially applicable to the coastal areas. The influence of swill infection shows a close parallel to the numbers of livestock with 31 primary cases in the eight counties against 191 in the rest of the country, a proportion of 1:6.

Table 1

Primary Outbreaks of Foot-and-Mouth Disease in Great Britain in the period 1/4/38—31/12/50

	Cattle and Sheep			Pigs
	Total Primaries	Swill Contact Possible	Origin Obscure	
Lincs to Dorset	58	9	49	32
Rest of Britain	84	41	43	191
Total	**142**	**50**	**92**	**223**

There are thus substantial grounds for the contention that some factor other than those previously considered applies to the east and south-east coastal area. The obvious factor is proximity to the Continent and consequently a relatively greater exposure to invasion when the disease is active on the other side of the water barrier. The figures previously quoted cover a period deliberately chosen to avoid two periods of abnormal disease incidence in the coastal zone, the series of outbreaks beginning in October 1937, and again in November 1951. In 1937 a series of unconnected initial outbreaks began on October 16, involving the six coastal counties from Lincolnshire to East Sussex. Disease subsequently spread to the south-western counties and 268 cases were confirmed up to March 9, 1938, when the outbreak was finally controlled. In 1951, after the country had been clear of the disease for some 3½ months, a further series of unconnected initial outbreaks occurred in the eastern counties between November 14 and 18. In five days 19 cases of disease were confirmed between Scarborough on the North Riding-East Riding border and Writtle in Essex. Three single cases occurring in the West Riding, Nottinghamshire and Leicestershire did not spread, but the coastal infections continued to spread until 106 outbreaks were confirmed before the disease was finally brought under control.

Airborne Infection Our present knowledge of the pathogenesis of the disease does not permit any other conclusion than that these mass invasions were due to airborne infection. It has been suggested that the virus of foot-and-mouth disease, which is amongst the smallest of all known viruses, might be transmitted in particulate form by air currents alone, much in the fashion that pollen grains have been carried for very considerable distances. There are some grounds for this supposition. In field outbreaks in dry, windy weather fine strings of saliva from infected animals may be seen being carried off in the wind current. How far this material will travel and how long virus will remain viable under such conditions is a matter for conjecture, but where this has been observed further outbreaks of disease have been exceptional and limited to premises in the immediate vicinity. There has been no suggestion at any time that the virus may be carried over land for as far as 22 miles, which would correspond

to the shortest over-water route from the Continent, and we have no reason to believe that virus will travel further in the relatively cooler sea atmosphere than it will over land. So far as east coast infections are concerned, the distances involved—at least 100 miles—and the prevailing adverse wind currents completely rule out particulate transmission.

Thus we are reduced to birds as carriers. The two major epidemics in 1937 and 1951 coincided with waves of wide-spread infection on the Continent, particularly in Holland and Belgium. They also coincided with the seasonal migration of various species of birds from their summer haunts in the Baltic countries and Central Europe to winter quarters in Britain.

The Bird Transmission Theory The earliest reference to birds as vectors of infection seems to have been made by Mettam (1914)[2] in a consideration of the possible origins of the Irish outbreak of 1912. He laid no special emphasis on birds in general but neither did he entirely rule them out of reckoning. Sir Stewart Stockman in his Annual Report for 1919 considered birds to be improbable carriers but thought the possibility of airborne transmission deserved further inquiry. In 1923, Stockman and Miss Garnett[3] made an attempt to correlate bird migration between the Continent and Britain with the then unexplained primary outbreaks. They set out to establish a negative by endeavouring to eliminate rather than incriminate birds. No particular species was considered, the authors confining themselves to a general treatment of the subject and concluding " the circumstantial evidence as a whole is very far short of establishing a negative case." As, at that time, the role of the swill tub was not appreciated, conclusions of this nature were vitiated in advance. In 1942, Bullough[4] published an extensive study on the relationship of starlings and foot-and-mouth-disease. He gave an excellent *resume* of the ornithological aspects of the case and then attempted to establish a *prima facie* case against the starling on purely statistical grounds, both as an agent in the autumn infections of this country and spring infections of the Baltic countries. Surprisingly enough, for it was then 1942, he also failed to appreciate the role of the swill tub and, with a limited understanding of the factors involved in the spread of the disease, was unable to assess correctly the value and meaning of his not inconsiderable data. Following a critical review of Bullough's paper by Dr. Landsborough Thomson in 1943[5], there does not appear to have been any further attempt to deal with the subject other than in the form of topical articles in the press.

The bird transmission theory was at one time the subject of some small-scale investigations by Eccles[6] at Pirbright. There, great difficulty was experienced in clinically infecting wild birds. One starling was so affected but the disease did not spread to other birds kept in close contact. Again using starlings, it was found that birds infected by mouth excreted virus in their droppings from 10 to 26 hours after ingestion of contaminated material, but there was no suggestion that virus multiplied in the system of the bird. After external contamination of feet and feathers, virus was recovered up to a maximum of 91 hours. Birds exposed to natural infection and flown directly to healthy animals transmitted infection with one of three viruses. Birds similarly exposed to natural infection and then held in isolation for 4–5 hours failed to transmit the disease.

There is, of course, no possibility of reproducing these trials under completely natural conditions. It is highly probable that exposure to the diluting effect of air currents and rain results in some shortening of the viability of virus in external contaminations, but this could well be offset

by the lower temperatures. Equally, removal of the fear complex in the natural state might reasonably be expected to prolong the period before complete elimination from the alimentary tract. For practical purposes we must assume that birds in their wild state do not become clinically affected with the disease or, in other words, do not become manufacturers of virus. But they may carry infection on their bodies for a time, probably measurable in hours, dependent upon the extent of the original contamination in relation to the prevailing weather conditions, and they definitely harbour infection for up to 26 hours after ingestion of contaminated material. Thus they are merely vehicles in the mechanical transmission of virus. On this basis, the role of any species of birds as potential vectors of foot-and-mouth disease can be assessed in mathematical terms as a function of their numbers, habits and opportunities for acquiring infection.

Birds have been blamed for the local spread of infection from known foci of disease in this country. Outbreaks in grazing stock, especially where outside trough feeding is practised, provide excellent conditions for external contamination of birds and for the ingestion of infective material. Reports from field staff on outbreaks in trough-fed sheep in downland country frequently comment on the large numbers of birds observed congregating around or on the flocks. In such circumstances the time involved in moving from one flock to another is only a matter of minutes. One cannot escape the conclusion that in field infections the mobility of birds makes them highly probable and dangerous disseminators of infection.

Bird Migration On the wider question of introducing disease from the Continent, it is necessary to study the movements and species of birds which could be incriminated.

Our British birds may be divided into four groups :

1. Native species which remain within the confines of our shores at all seasons.
2. Native species which leave our shores for warmer climates each autumn and return in the spring.
3. Birds from the Arctic region, northern and central Europe and the Low Countries which winter with us to escape the rigours of winter in their breeding areas.
4. Birds as in group 3 which merely use this country as a port of call on their way to warmer climates.

The general direction of the autumn migration of species which affect Britain are shown in Fig. 1. In the main, the spring migration follows the autumn lines in reverse.

Fundamentally, the autumn movements of birds are the sequel to falling temperatures reducing the available food supply in their breeding areas, but throughout countless ages these flights have become such an integral part of the lives of the birds that they are now performed almost instinctively. It may be that the movement also serves a useful purpose as an application of nature's law of " the survival of the fittest," in that immature or weakly birds unable to make the journey would inevitably perish during the winter in the breeding areas.

Fig. 1. Map showing the principal migration routes of birds to the British Isles

Our autumn visitors come from two distinct sources conveniently considered as northern and east-west. The northern stream, originating from Iceland, Norway and Arctic Europe, strikes our shores in the Shetlands, Hebrides and from Cape Wrath to the Humber Estuary. Some portion of the stream remains to winter in coastal or inland areas, but the majority skirts our coasts in a general southerly direction on their way to more temperate climates.

The east-west stream is drawn from the Baltic area, Central Europe and the Low Countries. Migrants from Central Europe travel down the river valleys of Germany to join birds from the Baltic and then skirt the coastline in a south-westerly direction to the Low Countries, where they may congregate in great numbers before making the sea crossing. Given favourable weather conditions, groups of birds may make a direct crossing to England from the Friesian Islands, and even from Denmark, but the majority follow the coastline to the estuaries of the rivers Rhine, Maas and Scheldt, thus ensuring the comparatively short sea crossing.

Except when made as a sequel to sudden changes of weather, autumn migration is a fairly leisurely process. Daily journeys over land may amount to no more than 50 miles, so that the major part of each day is available for foraging. Sea crossings are made at a speed of 30–40 miles per hour. Thus birds may travel from Holland to Norfolk in 3–4 hours or to Lincolnshire in 6 hours.

Flight over water is generally directed due west, and the greater mass of the birds strikes our shores between Norfolk and the Thames estuary, with smaller numbers making landfall as far north as Lincolnshire. The majority penetrate inland and remain with us throughout the winter. Some, which have gone inland in the region of the Thames estuary, make a short overland journey to join with a stream skirting the Kent-Sussex coast and either continue on to winter quarters in Ireland or cross back to France. Weather conditions have a definite bearing on migration. Unusually mild or cold spells may delay or hasten the departure of birds from their breeding areas. High winds and rainstorms may hold up the sea crossing, so that large hordes of birds congregate in the normal areas of take-off, ultimately arriving in spectacular waves or "rushes". Adverse winds may tire migrants to such a degree as to affect the depth of their initial penetration into the country. In the same way, cross winds may blow birds off their normal course, with consequent landfalls at unusual points. In average years migration commences towards the end of September, rises to a maximum in the third week of October and is practically finished by the third week in November.

Later migrations on a much reduced scale may take place at any time during the winter months. These are not really migrations at all but rather hard weather movements of birds which would normally winter on the Continent, being forced to seek warmer quarters by extremes of cold or snow.

There is nothing in previous records to suggest that the spring migration of birds has been responsible for introducing infection into Britain. No doubt, several factors contribute to this position. Continental epidemics of foot-and-mouth disease tend to peter out during the winter months; housing of cattle on both sides of the Channel lessens the possibility of infection being picked up; birds have to make a longer sea crossing than their autumn counterparts; and last and most important, the spring movements of birds, being the result of a physiological urge, are performed in small groups and much more rapidly than the relatively leisurely autumn journeys where hordes of birds daily and feed frequently on the way.

Likewise there are no grounds for suggesting that disease has been introduced in the autumn by birds of the northern stream. Foot-and-mouth disease has rarely been confirmed in their areas of origin and certainly never in epidemic form. The majority of northern birds which winter with us do so in Scotland and Ireland, where primary outbreaks of undetermined origin are rare.

Bird Species in the East-West Migration Having reviewed bird migration in general, and eliminated two of the three movements from further consideration, it is now necessary to study those species in the east-west stream which, on account of their habits and numbers, might be responsible for the autumn introductions of the disease into this country. A large proportion of our autumn visitors arrive as immense mixed flocks of rooks, jackdaws, starlings and skylarks. These four species are all essentially pasture feeders and thus have continuous opportunities for contact with grazing stock. As potential disease carriers, the differences

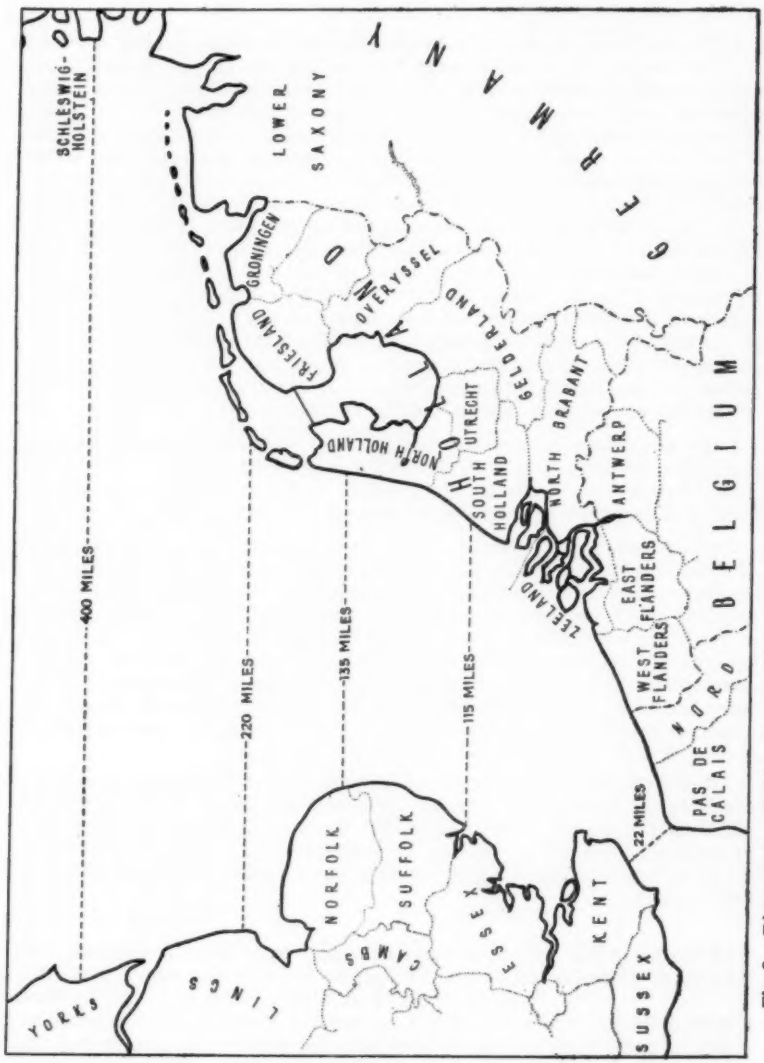


Fig. 2. Distances travelled by migrating birds using the east-west route, showing also the relationship of coastal areas

between them are only a matter of degree based on their habits and numbers. Skylarks appear to avoid animals, rooks and jackdaws do not avoid but rather ignore them, whilst the starling appears to make a special point of keeping close to grazing stock.

Continental lapwings arrive with the mixed autumn "rushes", making landfall from Yorkshire to Kent to winter very largely in the Humber and Thames estuaries. This species, in company with skylarks, also takes part in the winter hard weather movements from the Continent.

Wood-pigeons use the east-west route but are of less importance than most species, in that they do not regularly frequent pasture-land.

Wild ducks, chiefly mallard and teal, come to this country from the far north ; many winter on the Continent. The Continental birds, however, may be forced by severe weather to seek shelter on the mud flats and marshes of the south-east coast, where contact with cattle by way of drinking pools might readily be made.

Wild geese, particularly grey geese, migrate similarly to ducks and they also adopt winter migration when the marshes of the Baltic and Dutch coasts are frozen. Grey geese feed regularly on pastures and do not penetrate far inland.

Gulls of various species are common residents in this country. Following their breeding season, they migrate to the coast and with the onset of colder weather tend to move southwards, where they are joined on the south-east coast by Continental visitors. Stormy weather at sea drives the gulls inland to roost in sheltered bays, inland lakes and secluded fields and marshes. The number of birds in a roost may be enormous, as in the case of Littleton reservoir in Middlesex when the largest estimated total in 1940 was 45,000. Larger species of gulls are carnivorous and are great scavengers. Rubbish dumps, especially those containing waste food products and possibly meat and bones, are commonly visited by swarms of gulls, while ships in harbour or in coastal waters are besieged by gulls waiting to devour any waste foodstuffs. Undigested food is voided in the form of pellets, commonly found near the roosts and in fields and marshes. From their frequent and indeterminate wanderings in coastal areas, their propensity to feed on garbage and ship's swill, and their ability to regurgitate undigested food, it would seem fair to assume that gulls might readily constitute a direct vehicle in the transmission of disease to cattle and sheep from infected swill.

The Starling The association of the starling with grazing stock and their pastures which has already been noted, is a matter of common knowledge to anyone with practical experience of livestock husbandry. Starlings are almost omnivorous, but under normal conditions live largely on insects and molluscs. They tend to keep closely together in flocks which move over the pastures excavating for food particularly in the immediate vicinity of grazing animals and frequently within inches of their noses, almost as if the process of grazing was exposing suitable food material for them. It is not an uncommon sight to see starlings perched on the backs of cattle and sheep. In winter, when the ground is frozen or snow covered, starlings flock in the vicinity of houses and farms and groups of them enter cattle yards in search of grain or other edible material. No other British bird, whether native or migrant, shows such an affinity for close contact with livestock as does the starling. When ground is contaminated with infective saliva the chances of picking up infection or otherwise becoming

contaminated need no elaboration. Starlings have a further feature distinguishing them from most other species which may have a bearing on their disease-spreading propensities. During the hours of darkness migrant starlings roost communally in tall buildings in cities, in woods, in hedges and in reed beds which soon become heavily contaminated with their droppings. During the day they sally forth to feed in numerous small flocks, returning to the same point each evening. In roosts, which may contain up to 50,000 starlings, the birds are huddled so closely together that infection could readily be transferred from bird to bird. As to numbers, the starling is the greatest single factor in the east-west stream. Moreover, its numbers are thought to have increased substantially during this century and to be still increasing.

Summarizing the foregoing on the basis that birds are mechanical vehicles in the transmission of virus, the starling by it habits and numbers is an obvious choice as chief suspect. This, of course, does not imply that other species can be entirely ruled out, but merely that their role is likely to be incidental to any played by the starling.

COMPARISON OF BRITISH AND CONTINENTAL INFECTIONS

In General Applied to birds on migration, the habits and numbers of any of the species previously considered remain a fairly constant factor from year to year, the only variable being the degree of exposure to infection. Thus if birds are to be incriminated for introducing infection, we should expect to find a definite correlation between the extent of infection in certain areas of the Continent and the number of primary cases along our east and south-east seaboard. Looking over the records of British and Continental infections since 1890, it is at once obvious that, apart from the years 1922–24 when the disease almost got out of control in this country, fluctuations in the incidence of disease in Holland, Belgium and the Pas de Calais area of France show a remarkable degree of similarity to the position in Britain. This is just as might reasonably be expected as, until the Importation of Carcasses (Prohibition) Order came into operation in 1926, we were regularly importing potentially infected carcasses from these countries.

Since 1926, inquiries into the origin of all outbreaks have been conditioned by the knowledge that infection may have been introduced through the agency of chilled meat products from abroad. We have been assisted in this by our ability to classify viruses by typing. Since 1930, with the exception of a short period in the early part of the second World War, material has been submitted for typing from every outbreak not obviously connected with previous centres of disease, and has served a very useful purpose in correlating or separating the origins of parallel infections. This was particularly well demonstrated in the 1951 series of outbreaks when one geographically isolated case in Berkshire was typed as group "O", whilst material from some twenty parallel cases in the eastern counties were all group "A".

To determine the origin and status of any outbreak, it is essential to have individual case records. As available records date from 1937, further comparison will be limited to the period since that date. Table 2 gives comparative figures of total outbreaks for the months of September, October and November in each year since 1937 for Holland, Belgium and the Pas de Calais area of France and also the number of primary outbreaks in the south-east coastal counties of Britain.

Table 2

Total Number of Outbreaks										Primary Outbreaks in 8 Coastal Counties of Britain
Holland				Belgium			Pas de Calais			
Year	*Sept.*	*Oct.*	*Nov.*	*Sept.*	*Oct.*	*Nov.*	*Sept.*	*Oct.*	*Nov.*	
1937	11444	37998	31230	4090	14098	22321	(Epidemic)			20+
1938	34905	39623	17257	3642	3816	4960	191	37	68	7
1939	17925	13198	3818	775	1199	2333	801	214	81	3
1940	66	53	34	1758	1027	547	(Occupation)			1
1941	2492	2191	904	141	105	67	125	93	59	—
1942	301	309	1917	9	9	7	3	1	5	—
1943	9708	7618	2605	—	2	6	1	—	1	1
1944	3933	6183	4085	1132	1411	967	—	1	—	—
1945	28	38	73	2	2	23	—	—	—	—
1946	4596	4587	3183	1076	2136	3009	2451	1947	1184	7+1*
1947	8	3	2	3	2	2	—	2	2	—
1948	17	48	339	448	773	272	406	563	458	3+1†
1949	200	245	324	14	6	3	50	14	19	2
1950	102	148	170	2	—	34	—	5	2	—
1951	109	3485	12357	47	6261	23613	15	27	196	20+

* Includes one case in Herts.

† Includes one case in Wilts.

Note. We have been warned that the Continental figures for 1940-45, i.e., the occupation years, are possibly exaggerated, as a report of foot-and-mouth disease was the invariable excuse given to the occupying authorities when inquiring into reduced farm output.

Comparable figures for Denmark and Germany are not detailed, as they appear to have little or no bearing on British infections. For example, Denmark had only two outbreaks in the period September-November 1937, when we experienced a major invasion. In the same months of 1938 Denmark had 69,883 outbreaks, whilst we had only 3 cases in the eastern counties. Again, in 1951, Western Germany, and especially the coastal provinces of Schleswig-Holstein and Hanover, experienced a very severe epidemic during the months of September and October, yet Britain remained free.

Table 2 indicates that there is a definite correlation between the disease position on the opposite shores of the shorter crossings of the North Sea. In seasons of high Continental incidence our figures move up in sympathy, and conversely we may escape entirely when overseas incidence is low. The monthly totals given are those for the whole of Belgium and Holland. However, the regular disease bulletins issued by their Governments detail the outbreaks of disease in the various sub-divisions or provinces of each country. Comparison of the dates of our primary south-east coast infections with such of these records as are available reveals that the danger to Britain is greatest and in fact only exists when disease has attained definite proportions in certain coastal provinces : in Belgium, the provinces of East and West Flanders ; in Holland, the provinces of South Holland, North Brabant and, to a less degree, Sealand. These are the areas where the major part of our autumn visitors congregate before starting the sea crossing to our shores.

In 1937 and 1951 figures suggest that the risk is greatest on a waxing infection, which is in accordance with the accepted tenet that the infectivity of a virus is greatest in the earlier stages of an epidemic. That the coastal provinces of Belgium and Holland and the Pas de Calais zone of France are

statistically the areas of menace to this country might be said to be a normal expectation. It does, however, restrict the potential danger zones to a much smaller area of the Continent than had previously been believed.

In Recent Years The contention that the risk of introduction of disease by migratory birds is determined by the degree of infection in the areas of take-off for their sea crossing gains a large measure of support from the following table :

Table 3

Total Outbreaks of Foot-and-Mouth Disease in Belgium and Holland

	July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*
1937	12	711	15534	52096	53561	37829	12011
1951	32	31	156	11459	35920	22802	

In the 1937 series, disease first appeared on October 16 in Norfolk, with further primary strikes in that county, Lincolnshire, Suffolk and Essex before the end of the month. But in 1951 disease did not occur until November 14, that is, twenty-nine days later than in 1937. Examination of meteorological records fails to show any reason why migration in both years should not have been a continuous and unchecked process throughout the normal period. The autumn of 1951 was unusually mild, which may have resulted in some birds coming over later than usual and maybe after the end of the normally accepted migration period, but migration is such an ingrained instinct in birds that in the absence of adverse flying conditions it appears reasonable to assume that a comparable number of birds would have made the sea crossing by the same dates in each year and that the later appearance of disease in Britain in 1951 was entirely due to the later date of the build-up of disease in the Low Countries.

In dealing with an infection so highly contagious as foot-and-mouth disease, it is a matter of some difficulty to arrive at a decision as to which are primary or secondary outbreaks in invasions of this nature. It is accepted that as soon as symptoms of disease appear in any animal in these islands the risk of lateral spread is immediate. Making due allowance for this and other possible factors in the dissemination of virus, the primary outbreaks in the early stages of both invasions have been plotted in Fig. 3.

These indicate that in 1937 twenty-three primary outbreaks occurred in the period October 16 to November 9, involving all the coastal counties between Lincolnshire and East Sussex. Assuming the time interval from infection to confirmation of disease to be six days, then virus was being introduced into this country between October 10, and November 3, which coincides with the period of maximum extension of disease in the Low Countries in that year and also with the normal peak period of migration. All materials sent for typing were of a common strain "O" and identical with the type then decimating Continental herds. The 1951 series started in a more explosive manner with twenty primary cases in the seven days November 14 to 20. No cases occurred south of the Thames estuary, but there were no less than five north of the River Humber, an area not generally regarded as a major landfall for birds taking the east-west migration route. This may be explained by the constant south-west winds which prevailed during most of the autumn diverting birds northwards off their route with resultant landfalls further up the east coast. Using the same yardstick of

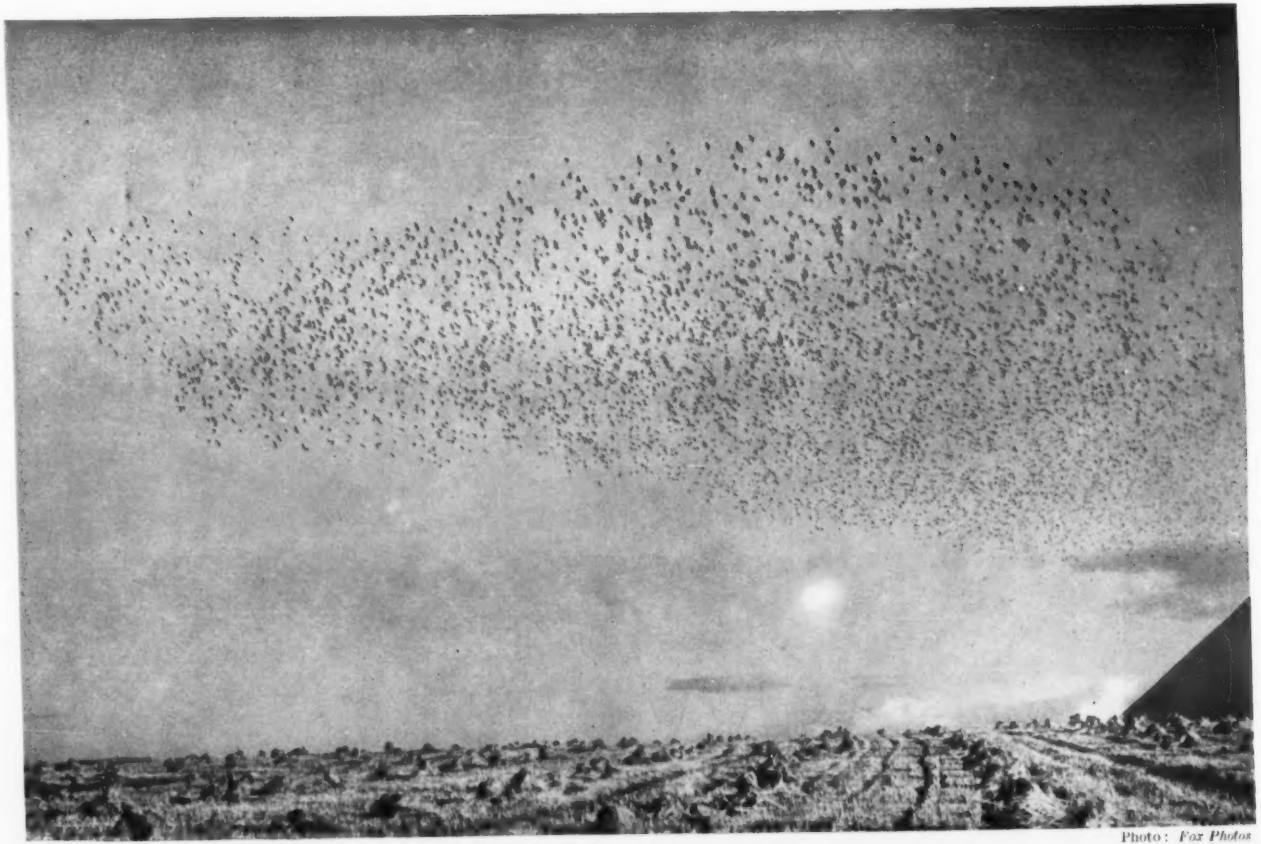
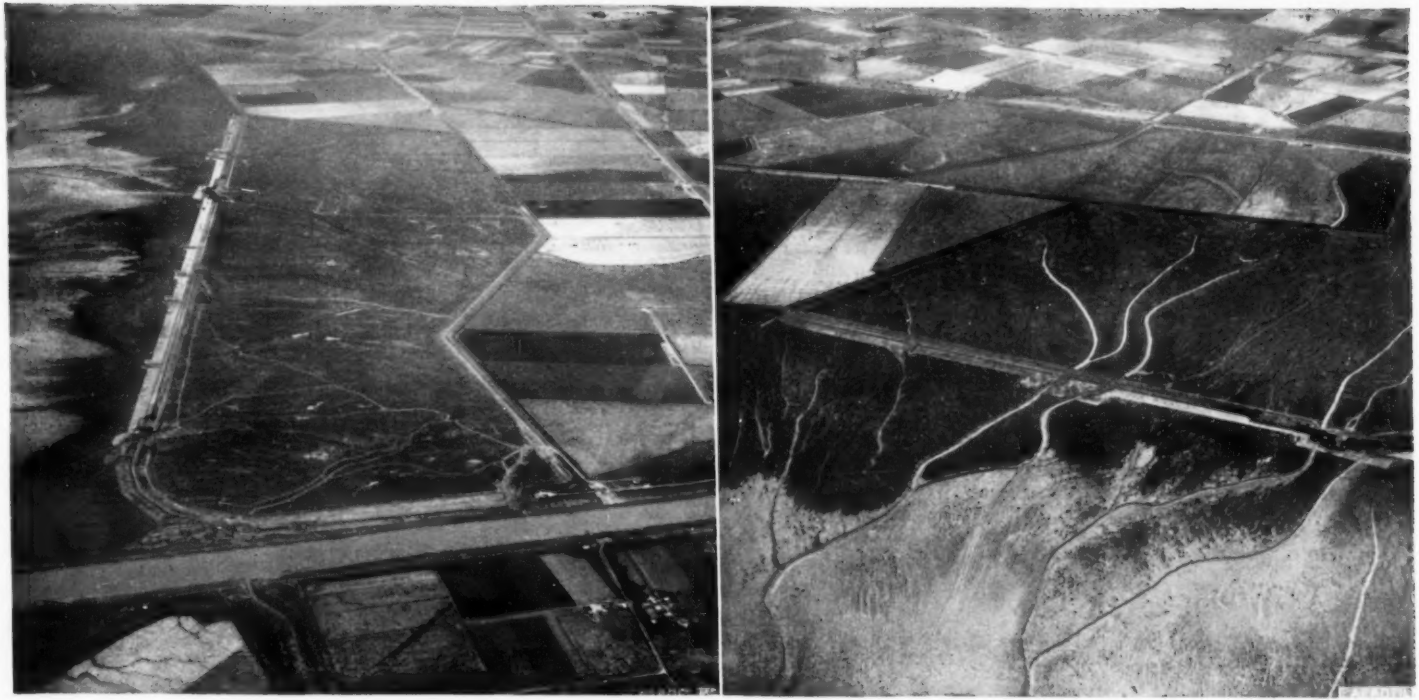


Photo: *Fox Photos*

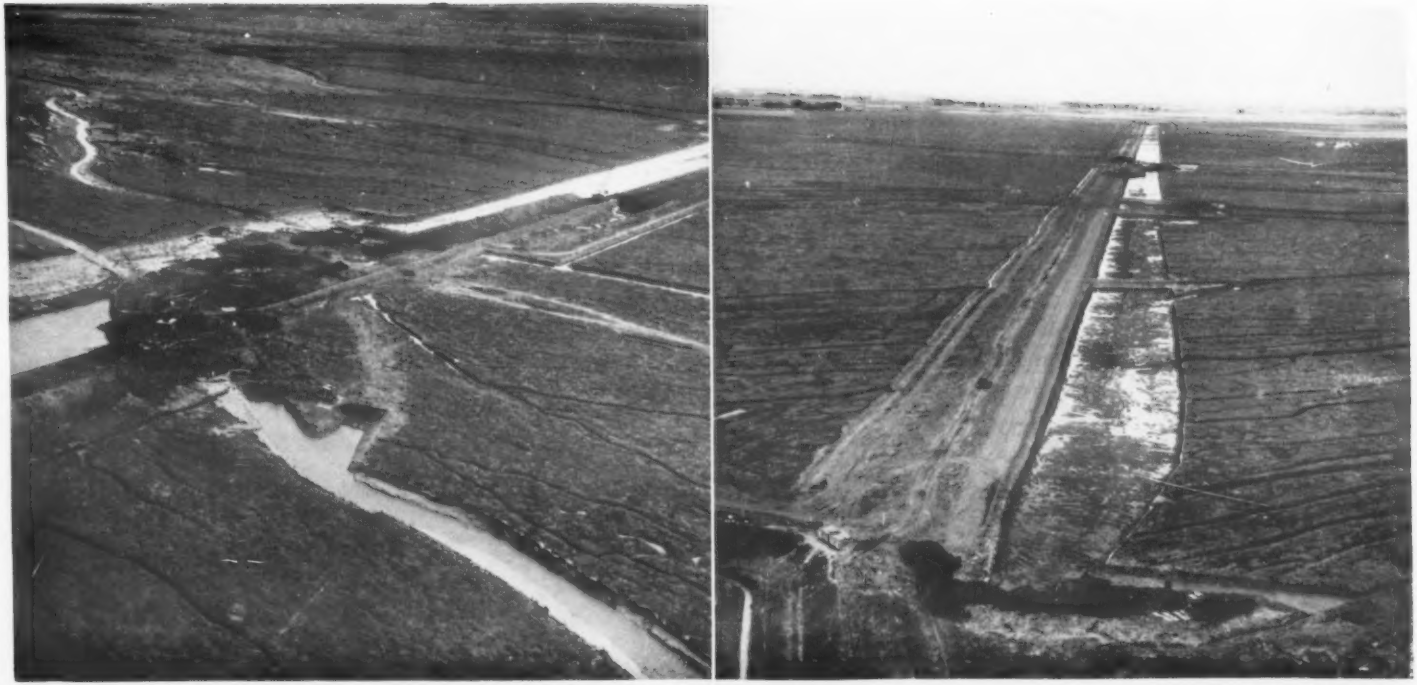
By mid-September starlings are beginning to arrive in Britain in large numbers.



Photos: *The Dredging Construction Co.*

Reclamation at Wingland

A general view of a reclamation scheme carried out last year on the eastern side of the outfall of the R. Nene. The area enclosed was just over 700 acres. One of the major difficulties when enclosing the area was to secure the safety of the embankment at the points traversed by old creeks. The photograph (*right*) shows a number of old creeks crossing the site of the new embankment. The remnants of old creeks can be seen on the landward side of the old reclamation embankment.



Photos: *The Dredging Construction Co.*

Reclamation at Wingland

Special precautions were necessary at the point where a large creek (on the site of the old course of the R. Nene) crossed the site of the new embankment. Material for the construction of the embankment has been obtained by digging a wide borrow pit on the seaward side.

VEGETABLE WASHING (See pp. 239-41)

Photo: *N.I.A.E.*

Left: Rotary vegetable root washer, consisting of inclined rotating wire mesh drum, feed-in opening and picking-over elevator. Water is supplied from pipe above.

Right: Simple equipment used for washing celery. (Semi-rotary pump, galvanized tank and soft brush.)

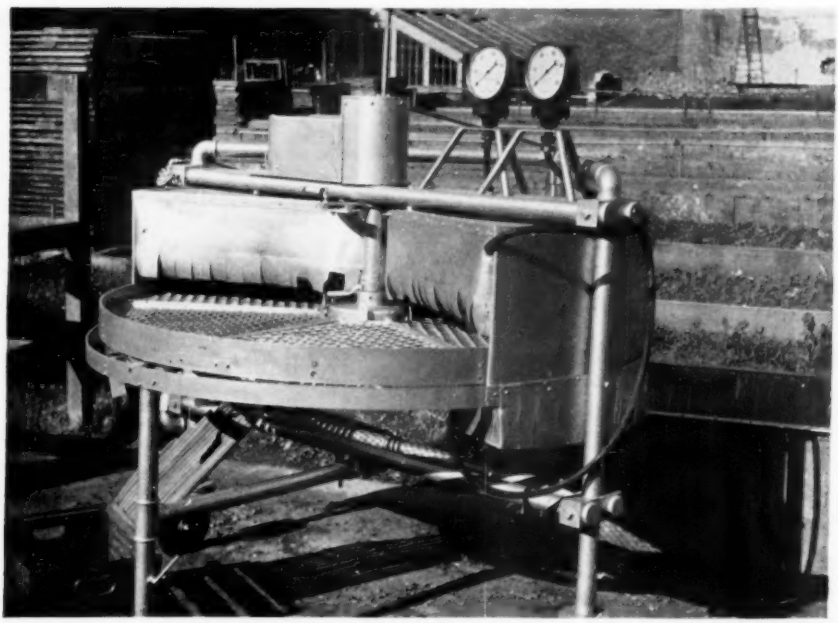


Photo: *N.I.A.E.*

Circular universal vegetable washing machine driven by reciprocating water motor through endless chain and free wheel sprocket.

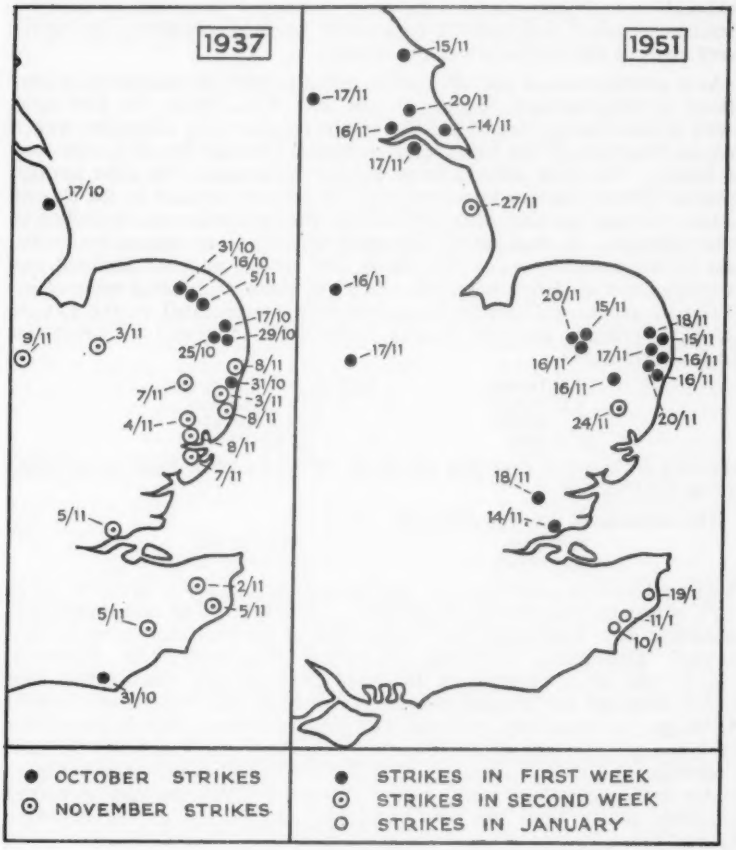


Fig. 3. Location of primary outbreaks ("strikes") of foot-and-mouth disease in England in the early stages of the invasions of 1937 and 1951.

six days from infection to confirmation of disease, the major crossings of the North Sea necessary to give rise to the 1951 infections would take place between November 8 and 14, a period accepted by ornithologists as within the normal migration range. With the exception of the Berkshire case previously noted, all materials sent for typing were returned as strain "A", again identical with the type current on the Continent.

There can be little doubt that in both years further primary strikes occurred at dates later than those shown in Fig. 3, but secondary cases arising from original centres of disease progressively confuse the general picture until a point is reached where one is not justified in attempting to establish primary strikes, except in very isolated cases. In the 1951 diagram only two such

cases are indicated, but undoubtedly there were others. Reports from the field staff in both years stressed the large number of birds seen on infected premises or which had recently been noted on these premises. In nearly every instance the emphasis was on starlings.

As a continuation of the 1951 series, three primary outbreaks were confirmed in Kent between January 10 and 19, 1952. These, the first cases south of the Thames, are of particular interest since they coincided with a definite extension of the Continental epidemic into the Pas de Calais area of France. We have already made passing reference to the close parallel between British primary infections and the disease position in the Pas de Calais. During the five years 1941–45 the Pas de Calais was virtually free from infection. In that period the only primary autumn case in the south-east coastal counties was in Norfolk in 1943, at a time when Holland was experiencing a moderate epidemic. In 1946, however, when a wave of infection in the Low Countries was especially concentrated in the Pas de Calais, 8 primary cases in grazing cattle were confirmed in south-east England as follows :

18.10 Dorset	4.12 East Sussex
9.11 Suffolk	11.12 Hertford
23.11 Suffolk	19.12 Dorset
24.11 Kent	25.12 Dorset

Material from every case was typed as "O"—the same type as prevailed across the Channel.

The sequence of the 1948 outbreaks was :

4.11 Wilts	23.11 Norfolk
23.11 Hants	19.12 West Sussex

Again, all were in cattle on open grazing and again, all were typed to strain "O", as was the parallel French infection. It will be noted that south coast infections have tended to occur rather later in the year than those in East Anglia. The January 1952 series in Kent follow the same trend. However, Fig. 3, with its comparison of 1937 and 1951 primary cases, shows four strikes south of the Thames between October 31 and November 5, 1937. Although, unfortunately, we have not detailed French disease figures for 1937, the spread of the epidemic in that year was from France into the Low Countries, and at the relevant period the Pas de Calais was experiencing a major epidemic. Conversely, in the autumn of 1951 the disease spread relatively slowly from the Low Countries into France as the following figures show :

Table 4
Number of Outbreaks of Foot-and-Mouth Disease in Pas de Calais 1951-52

Period to	15/9	30/9	15/10	31/10	15/11	30/11	15/12	31/12	15/1
Outbreaks	—	4	6	21	33	143	276	333	619

Again using the yardstick of six days from infection to confirmation of disease, the time of contraction of infection in the Kent outbreaks was between January 4 and 13. The maximum expansion of disease across the Channel was in the period January 1 to 15.

The sequence of events in the Channel area in December-January gives additional support to the previous contention that the prime essential for the spread of disease to this country is a certain level of infection in an appropriate area of the opposite shores. We appreciate that the period covered by this inquiry is not sufficient to justify any opinion being expressed on the apparent tendency for south coast outbreaks to occur later in the year

than those in East Anglia. The impression may prove to be ill-founded but if correct may be due to later migrants making use of the shortest sea crossing in the Pas de Calais region or to hard weather movements of birds.

The Time Factor Only one general point remains for consideration—the influence of the time factor. Experimental work by the Foot-and-Mouth Disease Research Committee established the capacity of the virus to remain viable under optimum conditions for as long as four months. Eccles's work at Pirbright gave optima of 91 hours for external and 26 hours for intestinal contaminations of birds. We have no means of assessing whether these times are maintained under natural conditions. Whether external or internal contamination of birds is the more probable means of carrying infection is a matter for future experiment. For the purposes of this article we accept both methods as possible.

Statistically, the danger areas are within 5–6 hours flying time of any of the normal landfall areas of our east coast. Migration from these areas is made in daytime and at a season when there are at least 10 hours of daylight. Even on the longest sea trip from Holland to Yorkshire, there is ample time for birds to feed both before and after the crossing and thus to have contact with animals in both countries in the same day. But the shorter the sea crossing the less will be the effect of rain and air currents in diluting surface contamination on a bird and of virus being eliminated from its alimentary tract, and consequently the greater will be the chance of viable infection being left on pastures, feeding troughs or on animals themselves.

That a time factor applies is obvious from the proximity to the coast of most initial strikes. It is not possible to say how far inland migrants penetrate before making a landfall. Doubtless this is largely determined by prevailing winds. But it is accepted that the majority of birds having made the sea crossing do not remain in coastal areas more than a day or two. The comparative absence of primary outbreaks in the Midland counties suggest that no great number of birds make a deep initial penetration of this country and also that they quite quickly became clear of infection. Applied to Continental migration, this would explain why birds coming from or crossing the heavily contaminated region of Schleswig-Holstein and Hanover in September and October 1951 did not bring disease to Britain ; they " cleaned up " in Holland, probably leaving disease in their wake. Likewise, Low Countries birds in November 1951 passing to the Pas de Calais would " clean up " in France before making the Channel crossing.

CONCLUSION

We have endeavoured to assess impartially the various factors having a bearing on the theory that birds on migration have been responsible for the introduction of foot-and-mouth disease into Britain. The seasonal incidence and location of primary outbreaks in the east and south coastal counties of this country shows a striking parallel to the period of autumn migration of birds and their area of landfall. We conclude that available evidence is adequate to establish a *prima facie* case against birds, and especially starlings on migration, as a means whereby foot-and-mouth disease is introduced into Britain ; further that the frequency of its introduction is dependent on the extent of the disease in certain coastal areas of the Low Countries and north-east France at the season of bird migration.

NOTE. Since this article was prepared there have been further outbreaks of foot-and-mouth disease in the spring and summer of 1952. Many of these occurred in the southern coastal counties of England. At the same time

there has been a build-up of infection in the northern coastal counties of France unprecedented in extent for the time of the year. The evidence suggests that in 1952 for the first time the spring migration may have been responsible for introducing infection into this country. Moreover, the continuance of further cases in the coastal counties throughout the summer while the intensity of infection in Northern France was still increasing raises the question whether in certain circumstances it is not possible for infection to be carried by cross-Channel movements of birds which are not part of the regular migratory movements.

ACKNOWLEDGMENTS

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INVESTIGATIONS INTO THE FIELD BEAN CROP

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Recent investigations at Oxford have revealed wide variations in the methods used by farmers in the cultivation of field beans. Research into particular aspects continues, but in the meantime, the general recommendations made in this article will undoubtedly be of considerable value in the quest for higher yields and healthier crops.

OVER the past five years a considerable amount of investigational work on field beans has been proceeding at Oxford, and while the detailed results are being published in scientific papers elsewhere[1,2] it is felt to be in the farmer's interest to publish a short account of some of the principal conclusions that have been drawn from the investigations.

The work began in 1947 with a field survey of crops of beans grown by farmers in the vicinity of Oxford, and this survey was continued over three consecutive seasons. The main object was to find out exactly what methods farmers were using in the production of the crop ; what were the main reasons for its apparent unpopularity ; and what problems called for specific research work. As a result of the first two years' survey, a series of field experiments were put down to test certain points which appeared to need immediate clarification, and these experiments, with others of a longer-term nature, have been continued each year.

One of the surprises of the investigation was the extraordinarily wide variety of methods used by farmers in growing the crop, especially when compared with the almost standard practice employed, say, with autumn wheat. Times of sowing, seed rates, fertilizer practice, and methods of sowing varied widely from farm to farm.

For the purposes of this survey, particulars of each field were noted under the following headings : (1) soil type ; (2) preceding crops ; (3) date of sowing ; (4) fertilizers applied ; (5) seed rate ; (6) row width ; (7) method of sowing ; (8) origin of the seed.

Soils and Fertilizers Taking the twenty-nine fields in the 1948 and 1949 surveys together, there was an average of 12,000 more plants per acre at harvest on the heavier soils, and though this difference was not statistically significant, the figure of pods per acre (which showed an increase of approximately 25 per cent on the heavier land) was definitely significant. This finding does support the practical belief in the superiority of heavy-textured land, though it does not necessarily mean that good crops cannot be grown on light soils. If the seed is put in early and manured well, good crops can be grown on the lighter types, as was proved by several fields included in the survey.

It was found that 90 per cent of the crops followed a cereal, and nearly 40 per cent followed two cereals in succession, but it was disturbing to find that half of the crops that were grown after two cereals (i.e., 20 per cent of all crops) were receiving no assistance either from fertilizers or farmyard manure. In all, nearly 40 per cent of the fields received no dressing at all (see Table 1).

Table 1

Analysis of Fertilizer Usage

Manures Used	Percentage of Total Crops (60)
No fertilizer	38.3
Farmyard manure only	16.6
Farmyard manure and fertilizers	6.6
Phosphate only	20.0
Phosphate and potash	5.0
Compound fertilizer	11.6
Potash only	1.9
	100.0

Only 23 per cent of the fields received farmyard manure, which is traditionally supposed to be desirable for high yields, and only 16 per cent had compound fertilizer or phosphate and potash together, which earlier experiments have shown to be desirable.

When the results from the 1948 and 1949 crops were analysed statistically, it was found that the " farmyard manure " fields produced significantly more pods per acre than the unfertilized fields, but the difference between the latter and the "fertilizer" fields just failed to reach significance. The calculated yields on a " pods per acre " basis were 15.8, 18.5 and 21.3 cwt. per acre for the " no fertilizer," and "fertilizer" and " farmyard manure " groups respectively.

It is difficult to avoid the conclusion that a reasonable level of manuring gives a worthwhile response and that farmers in general are not giving the crop sufficient help, especially in view of the previous cropping history of many of the fields. Suitable dressings for the crop are 3–4 cwt. superphosphate per acre (or 6–8 cwt. basic slag), with an addition of at least 1 cwt. muriate of potash, particularly if no dung is applied. Farmyard manure itself does not seem to be essential for the production of a good crop, but an adequate level of organic matter is certainly of great benefit ; whether it is derived from previous applications of dung or from the ploughing-in of leys is probably immaterial.

Sowing Dates and Seed Rates There is a good deal of evidence that the crop is being sown too late, and the actual dates of sowing in the survey varied between September 28 and November 25. Table 2 shows the average results when the sowing season is divided into three periods.

Table 2

Influence of Sowing Dates. 1948 and 1949

Date of Sowing	Plants per acre (July) *thousand*	Pods per acre *thousand*
(1) Before Oct. 15 (8)*	87	783
(2) Oct. 16-31 (13)	68.2	631
(3) After Nov. 1 (8)	63.9	595
Sig. Diff. 1 v 3	22.4	166
„ „ 1 or 3 v 2	19.9	152

* Denotes number of fields.

The beneficial effect of early sowing is clearly brought out by the analysis, particularly if sowing in the first fortnight in October is compared with that done in November. Not only does a far higher plant population result from the early seeding, but this beneficial result is carried through to harvest when there is a markedly significant increase in the number of pods per acre. Many farmers seem to fear winter proudness from early sowing, but this is not likely to occur unless the crop is actually sown in September.

In 1949 and 1950, detailed experiments were put down to compare both the effect of early against late sowing, and of high against low seed rates, using winter and spring beans. It had been suggested from the early survey results that on land above the average in fertility there were more pods per acre with the higher rates of seeding, but that there was no difference on low fertility land. On the whole, the evidence pointed to the desirability of a relatively high seed rate, even though some farmers expressed the view that it was dangerous to have too thick a crop. The results of the detailed 1949 and 1950 experiments are tabulated in Tables 3 and 4, and show that in 1949, when the autumn and winter were exceptionally mild, the difference between early and late sowing was quite insignificant.

Table 3

Yield of Winter Beans (cwt. per acre)

Sowing Date	1948-49				1949-50			
	Seed Rate (bushels per acre) 2	4	Mean	Sig. Diff.	Seed Rate (bushels per acre) 2	4	Mean	Sig. Diff.
Oct. 7	21.5	25.5	23.3	1.5	24.3	28.1	26.2	2.4
Nov. 7	21.7	24.3	23		20.2	25.2	22.7	
Mean	21.4	24.9			22.7	26.7		
Sig. Diff.		1.8				3.4		

In 1950, however, there was a significant difference of some 3½ cwt. per acre in favour of the early October sowing. In both 1949 and 1950, the higher rate of seeding at 4 bushels per acre gave very definite increases in yield, compared with the 2-bushel seed rate at both sowing dates ; the average differences were of the order of 4 cwt. per acre.

These experiments were carried out on good land under relatively high farming conditions and substantiate the conclusion drawn from the survey results, that is, that under fertile conditions a high rate of seeding is desirable. They also provide evidence, though it is less conclusive, that sowing early in October is advantageous. Experiments are now proceeding to determine the effect of finer differences in rate of seeding, and the interaction with them of fertility differences.

In both years very similar results were obtained with spring beans ; tick beans were used in 1948, and ordinary spring beans in 1949.

Early sowing and a high rate of seeding are both desirable with spring beans, the rate of seeding being even more important than with the winter crop owing to the markedly poorer branching capacity of the former. These two experiments also provided a comparison of the relative yields of winter and spring beans under the conditions existing on the farm in question.

Table 4

Yield of Spring Beans (cwt. per acre)

Sowing Date	1948-49				1949-50			
	Seed Rate (bushels per acre) 2	4	Mean	Sig. Diff.	Seed Rate (bushels per acre) 2	4	Mean	Sig. Diff.
March 7	13.1	17	15	1.1	14.1	16.1	15.1	1.4
April 7	10.2	14.6	12.4		7.9	11	9.4	
Mean	11.6	15.8			11	13.5		
Sig. Diff.	1.4				1.9			

Methods of Sowing Row widths and methods of planting are factors which vary from farm to farm. The most common method is to drill in rows 21–24 inches apart (80 per cent of the crops in the survey were planted in this way). On the remainder of the fields, the seed was ploughed in or drilled at widths of 7 or 14 inches. An accurate conclusion as to the advantage of each method could not be formed from the survey, but subsequent detailed research work which has yet to be published, suggests that row width is unimportant, provided density per unit area is uniform. The obvious advantage of wide rows lies in the ease with which the crop can be kept clean, and this is likely to be the governing factor in the decision as to the right width of drilling. If the crop is being planted after one or two cereals, the land is likely to be rather foul, and 21-inch rows are definitely to be recommended. Ploughing in the seed is a method which appears to be dying out, but it has an advantage in a wet autumn, when seeding might otherwise be delayed, and also on fields where bird damage is likely to be serious. It has the disadvantage of leaving rather irregular rows which are difficult to hoe. Taking all factors into consideration, drilling in 21-inch rows seems to be desirable, but deep drilling (3 inches) is essential particularly on puffy soils or hollow seedbeds. It is fatal to make the sowing too shallow or to allow the soil to fall away from the plant in a wet winter, as the stem tissue is then very easily damaged by low temperatures, and the plant will never fully recover.

Damage from Pests and Diseases Though underground damage to the tap-root by insects is widespread, and causes more wastage of plants than is usually appreciated, the main pests of the crop are birds and the black fly or bean aphid. Some fields originally included in the survey had to be ploughed, owing to the depredations of rooks, and wastages of 20–30,000 plants per acre were common. The later sown crops were far more susceptible, for the birds have greater difficulty in finding food when these late crops are coming through. The main precaution is deep and early sowing, but a good preventative is black cotton strung across the field in approximately 20-yard squares, some 2 feet from the ground.

The experience of the survey and observations in subsequent years suggest that the bean aphid is not a serious pest of winter beans in the Midlands, though it may cause considerable damage to the spring-sown crop, particularly if sowing is not carried out early in March.

The farmer also fears Chocolate Spot (*Botrytis cinerea*) and to a less degree, Stem Rot (*Sclerotinia trifoliorum*). Three years detailed study of farmers' crops and two further years of observation suggest that Chocolate Spot is likely to assume serious epidemic proportions only when the level of available phosphate or potash in the soil is low, though it appears in practically every crop in a non-aggressive form. This observation, of course, refers only to the S. Midland district ; the disease is more likely to be serious in the wetter western areas where fungus diseases spread more easily, or in a particularly wet season. Most farmers appear to be unduly apprehensive about the disease, but they have little to fear provided they do the crop really well.

Development of the Plant The plant, stem, and pod counts carried out on the various crops brought out some interesting relationships, and in a paper to be published elsewhere(1), the effects of season, plant density and fertility level are analysed and discussed. It is clear from the catastrophic results of the 1946–47 winter that many strains of beans in use today are not frost resistant, and that some mortality is to be expected in a really hard winter. It is also apparent that this mortality is not confined to the winter, for plants continue to die right up to the time of cutting the crop. Another finding of interest is that the really hot, dry seasons do not provide the best conditions for high pod formation, but rather those years with a mild, sunny spring and a summer with an average rainfall. Neither 1947 nor 1949—both of which had hot, dry seasons—gave very good podding results.

A negative correlation between pods per stem and plants per acre was found under all conditions, i.e., as plant numbers increase, the number of pods per plant decreases, and the rate of decline is more rapid on the low fertility fields than it is on the high.

It was possible to show that, in a good growing year, relatively low plant numbers could be partially offset by increased branching and podding, so that ultimate yield compared favourably with the higher density fields ; but this occurred only when the season was especially suitable, as in 1948. Taking all crops together, no evidence of relationship could be obtained between plants per acre and pods per acre, but the division into high and low fertility fields clarifies the issue, for on good land the more plants there are per acre the greater is the number of pods produced per acre, whereas on poor land the opposite seems to occur. Thus it appears that if the crop is grown on land of above average fertility (as it most certainly should be) there is no danger of a high plant population affecting yield, whereas if it is grown on poor land (which is not advisable in any case), it might be risky to have very high plant numbers. Other factors, however, such as weed competition come into the picture and may make it desirable to use a relatively high seed rate in order to obtain a better smother. On balance the evidence supports the desirability of using a relatively high rate of seeding, i.e., 3–4 bushels per acre.

The pre-requisites for a good crop are, therefore, land in good heart, a fair level of manuring, sowing early in October, and a high rate of seeding. In addition, protection from birds and reasonably clean land (or as frequent hoeing as possible) are almost as important.

Growing Beans with Cereals Investigations into the effect of growing oats with beans, or vice versa, have been conducted over the past three years, using both winter-sown and spring-sown mixtures. For a variety of reasons, these trials have not been entirely successful, and the correct balance between the two crops has not yet been determined.

In 1949, the addition of 2 bushels of oats to a seeding of 2 bushels of beans reduced the yield of winter beans by approximately 50 per cent, and an early sowing gave a still greater reduction than a later sowing.

There was a rather greater yield of starch equivalent with the mixed crop, but the decrease in the yield of beans reduced the quantity of crude protein per acre by nearly one-third. Compared with a full seeding of 4 bushels of beans, there was a small reduction of starch equivalent and a yield of only two-thirds of the crude protein from the mixed plots (3.9 cwt. per acre, compared with 6.2 cwt. per acre).

In the corresponding experiment in 1950, there was less suppression of the bean crop by the oats, the reduction in yield of beans amounting only to some 25 per cent, but this result was affected by a fungus infection which considerably reduced the influence of the oats. In 1951, using combinations of three rates of seeding with beans and two rates with oats, the reduction in yield of beans due to the oats varied between 40 and 50 per cent, but there was no significant difference between the two levels of oat seeding.

From the rather slender evidence yet available, it appears that the yield of starch equivalent per acre is not likely to be very greatly increased by the addition of oats to a bean crop, whereas the yield of crude protein is likely to be quite seriously reduced. On the other hand, the addition of, say, one bushel of beans to a crop of oats, may add some valuable crude protein to the yield, without materially affecting the total starch equivalent.

It must be emphasized that these conclusions are purely tentative, and they are included now only as a possible guide to those farmers who are inquiring about mixed crops at the present time. The complete answer cannot be given until further research has been carried out ; and even then, factors such as sowing date, level of fertility and the season are likely to affect the result.

Conclusions The evidence collected from the survey and from those experiments which have, as yet, been concluded, suggests that in practice many growers are not paying sufficient attention to the proper cultivation of the crop. In many cases, it is obviously being grown on rather impoverished and sometimes foul land as a break from cereals, and it is not being given a fair chance. The level of manuring frequently leaves much to be desired, and the survey does bring out the advantage of using land in a fairly high state of fertility, and the benefit of a dressing of farmyard manure, or a compound fertilizer containing phosphate and potash. The survey and subsequent experiments also emphasized the desirability of getting the crop sown early in October and of using a relatively high rate of seeding. If growers would pay the same amount of attention to the crop as they would pay to a crop of sugar beet or potatoes, there would undoubtedly be far less dissatisfaction with low yields, and probably also healthier crops.

There are many other factors which affect the success or failure of the crop, and many which still require more detailed research, but those that have been mentioned are probably the most important. If the recommendations that have been given are followed the risks in growing the crop should be very considerably reduced.

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TULL, TILLET AND BUNT

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Nowadays bunt disease of wheat is so effectively controlled by seed dressing that it is difficult to appreciate the magnitude of the problem it presented in Europe in bygone days. By the same token we are apt to overlook the debt we owe to Tull and Tillet, whose patient investigations into its cause and cure some two hundred years ago laid the foundation of our present immunity.

TULL, Tillet and Bunt is not, as it might appear to be, a firm of family solicitors. The first two words are the names of men who, two hundred years ago, contributed much to the improvement of agriculture ; bunt is the disease of wheat. Jethro Tull in England, who had introduced the horse-hoe and seed drill, examined the disease ; Matthieu Tillet in France ascertained the cause and popularized its cure. It is interesting and instructive to reflect on the work of these pioneers.

Today, this fungus disease is of little importance because its control, by the simple process of dressing seed with organic mercurials or other products, is a routine matter. Two hundred years ago, bunt attacks were so severe that in a bad year half the grain could be lost, and even in a good one many crops had sufficient bunt to give the detested violet shade and characteristic smell to the flour, which so much lowered its price. The making of gingerbread is said to have originated from the fact that, at that time, it was a means of disposing of bunted grain.

Many thinkers, philosophers and farmers speculated on the cause of bunt, and among them was Jethro Tull, who is, of course, famous for his book, *Horse-hoeing Husbandry* (1731 and 1733). In his book, which did so much to increase harvests, Tull had a chapter on "Smuttiness," and he showed, by means of some rather primitive experiments, that he believed the condition to arise from excessive wetness in the soil. The importance of this chapter was, however, that he gave a remedy, which was to dress the seed with lime and salt. He told the story, from hearsay, of the grain ship sunk in the Bristol Channel, and the salvaged grain which, when sown, produced perfectly healthy crops, whilst other fields nearby were badly diseased. One gets the impression that Tull did not really believe the story of the shipwreck, and he issued the *caveat* that the salvaged grain might have grown clean even without the sea salt, since it was a case of " change of seed," another method he advocated to ensure healthy crops.

Matthieu Tillet was a prominent French official in the town of Troyes, where he became Master of the Mint, He had a small farm, an inquiring mind, and became a member of the Academy of Science at Bordeaux. The enormous loss caused by bunt led this body in 1750 to offer a prize for the best essay on the subject, and it was this which inspired Tillet to carry out his really remarkable experiments in the winter of 1751–52—exactly two hundred years ago—and in the two subsequent winters.

We now know that bunt is a fungus disease perpetuated by means of spores on the skin of seed grain, or sometimes in the soil. These spores germinate in the ground and enter the young seedlings there ; they then grow within the plants until spores are reproduced again in the ear in the form of the familiar black bunt-balls and dust.

Though we may smile in a superior manner at many of the outrageous theories put forward to account for the disease in the early eighteenth century, we cannot but respect the exacting experiments laid out by Tillet so

long ago, which show almost every feature of a modern "replicated" or "randomized" field trial. Tillet was familiar with Tull's work, and, in fact, with Duhamel du Monceau, he translated *Horse-hoeing Husbandry* into French. But, he by no means accepted Tull's theory of the cause of bunt, maintaining that there was insufficient evidence in a single, small experiment to prove it, although he admitted that any or all of the current theories could be true. These were that it was caused by dampness ; by a "miasma" in the air ; by not changing the seed ; by using certain manures, such as sheep dung ; by the sun falling on wet ears ; and by many other causes save only the dust of bunt itself. Tillet's experiments were consequently designed with two main objectives ; first, to discover the cause of the disease, and secondly, to find a cure.

Tillet's Experiments His first experiment, laid down in October and November 1751, consisted of a hundred and twenty different plots, each 18 feet by 5 feet. It contained four different manurial treatments and a control, or no-fertilizer plot, six different sowing dates and seven different seed treatments. These were : (1) pure, clean seed ; (2) naturally bunted seed ; (3) pure seed dusted with the black bunt dusts ; (4) a mixture of (2) and (3) ; (5) seed treated with nitre and lime ; (6) seed treated with salt and lime ; (7) seed treated with lime alone. The whole experiment was in four rows each 540 feet long, with the blackened, undressed seed down the outside of one row of plots.

Reading Tillet's book, published in 1755, one can sense the tremendous excitement with which he watched the corn on the plots form clean and bunted ears. The presence of about two-thirds infection of bunt in his infected seed plots and its almost entire absence in the others led him to believe, as he says, " that a virus resides in the black dust," which was transmitted to the seed. He took no crop records from the individual plots but only from the different manurial treatment blocks. They did not differ much from the control, but he was satisfied that his disease-free plots gave twice as much grain per *arpent** as the ordinary crops in the neighbourhood that year.

The success of the 1751 experiment led him to repeat the trial on a bigger and more elaborate scale in the winter of 1752–53. This time the plots were larger and to some extent randomized, and at the harvest he carefully counted the number of healthy and attacked ears in most of the plots. He also included several varieties of wheat, some oats, barley and ryegrass. Some plots had dung made from clean straw and others had dung from straw which had borne bunted ears. The same seed treatments were used, but additional plots were laid down to see if the smuts of oats and barley could be transmitted to wheat.

Again, reading Tillet's careful description of the trial, one feels the excitement and pleasure he experienced in the unfolding of this remarkable experiment which, in spite of his own and those popularly held but completely false theories, led him to an inescapable conclusion. His feelings are illustrated by the following quotation from his preface : " Perhaps the best method of freeing men from an untrue hypothesis is not to demonstrate its falsity by a methodical analysis through the use of simple reasoning, but to state that one was oneself once of this same false opinion, but that it has been abandoned with reluctance as incapable of further tenure".

* Formerly the French acre = approx. 1¼ English acres.

Monsieur Tillet's Experiment, 1752-53

(Autumn-sown wheat in all 120 plots, each 18 feet × 6 feet)

Tillet's Plot Numbers	No. of Plots	Fertilizer Treatment	Seed Treatment	No. of Bunted Ears per Plot			No. of Healthy Ears per Plot	Remarks
				Highest	Lowest	Average		
1, 6, 11, 16, 21, 31, 36, 41, 46, 51, 54, 56, 61, 66, 71, 81	16	None	Clean seed, untreated	11	1	4.3		In effect, the control plots
2, 3, 7, 12, 13	5	Farmyard manure : horse dung and clean straw	,,	14	1	5.4		
4, 5, 8, 14, 15, 52, 53	7	Farmyard manure : horse dung and infected straw	,,	49	11	35		
9, 17, 18	3	Farmyard manure : sheep dung and clean straw	,,	94	1	38	3,475	1% infection
10, 19, 20	3	Farmyard manure : sheep dung and infected straw	,,	879	10	571	2,439	19% infection
32, 33, 34, 35, 42, 43, 44, 45, 57, 79, 80	11	None	Seed dusted with bunt powder sometimes after coating seed with gum	1,687 938			2,026 331	Plot 42 (45% infection) Plot 45 (74% infection) Remaining plots had a maximum of 75% and a minimum of 33⅓% infection
37, 38, 72, 73, 78	5	None	Seed dusted with bunt powder, then dressed with salt and lime	10	A few			less than 1% infection
39, 40, 77	3	None	Seed dusted with bunt powder, then dressed with nitre and lime	4	Very few			less than 1% infection

It is not possible in this article to give details of the results from his 120 plots, but the table on p. 237 summarizes some of them.

There could be no doubt from this experiment that both his objects had been achieved. With what great satisfaction he must have written : " the usual cause, the abundant origin of this bunted wheat, is in the dust of the attacked grain . . . the preparations I used have guaranteed the most highly infected grain from the effects of the contagion, and the results are yet more marked when it is considered that the seed, when treated, always had on it much of the black dust with which it had been powdered".

A Practical Approach Tillet, although he had a detached scientific attitude to experiment, was a strictly practical man : he did not wish to indulge in philosophical speculations as to the basic causes of bunt but to be of service to agriculture, as a final quotation from his remarkable book will show : " Most of these remedies cost nothing : I repeat exactly nothing : others cost a little : all are practical. I have often felt that the farmer, who is often poor and reluctant to change his ways might be unwilling to face even a slight cost or the trouble of a special procedure. I have therefore tried to follow his vein of economy, to adapt myself to his customs and to be useful to him without crossing him."

Tillet never had any idea that he had to deal with a fungus, and it is perhaps unfortunate that he ruled out " philosophical speculations," as he would have found out the truth, seeing that he had already noticed the similarity between bunt and the dust inside old puff-balls. Nevertheless, his work had tremendous practical results. Treating seed grain with salt and lime, rotting urine or similar substances, became common, and increased Europe's crops enormously, so that soon, his successors, the Abbot Tessier and M. Prévost, were to find better seed dressings. The mycologist Tulasne eventually described the fungus, and he called it *Tilletia* in honour of the early French experimenter.

Today, when we still have need to increase our food production, we cannot afford to neglect the example of those two painstaking research workers, Tull and Tillet, and it is to be hoped that we continue to find people with the inquiring minds yet matched by practical approach to problems which were once found in those two men.

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VEGETABLE WASHING

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THE washing of certain salad vegetables prior to sale is traditional. The purpose is to improve the appearance so that the natural colour and shape are not disfigured by adhering soil or dirt smears. During the last half century an increasing number of different kinds of vegetables have been washed to meet a market demand for greater cleanliness and better appearance. There is a substantial price premium on most markets in favour of washed vegetables where washing is appropriate. But in some circumstances the washing of vegetables leads to a shortening of the market life of the product. The simpler methods of washing are still in general use ; the vegetables may be washed by moving them about in a tank or tub of water by placing them in a stream, or the overflow from a spring, or water may be splashed over them from a hose, with or without a "rose". These methods are not unsuitable on the smaller types of market garden and in fact, with a minimum of equipment, quite good outputs can be achieved ; Fig. 2 (p. iv of the art inset) illustrates the equipment used by one grower who washes 140 bundles of 12 heads of celery per hour with it. But these simple methods are not suitable where large quantities need to be washed in a comparatively short time.

There is a growing demand for machines that are capable of substantial output with economy in the use of water. The National Institute of Agricultural Engineering has taken an active interest in the design of vegetable washing machines (see Fig. 3, p. iv of the art inset). But early in their investigations the problem of deterioration following washing showed that some fundamental investigation and research into the effects of washing, of the different methods of washing and of mechanical handling and conveyance were necessary before the problem of design could be approached with confidence.

The problems were considered by the Agricultural Improvement Council, who suggested the need for surveys to show to what extent washing is practised, what methods of washing are used and how existing methods affect the keeping quality of vegetables, and also the need for further research.

The points on which research seems necessary fall into two divisions : (1) *Physical*—finding the best methods of removing dirt and exploration of the mechanisms of handling ; (2) *Biological*—finding out the effects of washing on the subsequent behaviour of the produce. In the latter connection two sets of factors will probably be operative ; namely, the effects of mechanical injury, and the effects of the soaking up of water by the tissues of the vegetable.

Preliminary work is in hand and surveys designed to show the effects of washing by methods in current practice are being carried out by a small scientific working party. The working party is composed of scientific and technical officers of the Ministry of Agriculture and Fisheries, Department of Scientific and Industrial Research, Ministry of Food and the National Institute of Agricultural Engineering and is responsible to a Co-ordinating Committee on which the Departments, the Agricultural Improvement Council and the Agricultural Research Council are represented. The survey relating to the extent and methods of washing vegetables has been completed* and points of interest from it are summarized below.

* Unpublished report prepared by A. G. M. Bean of the N.I.A.E., Silsoe, Beds, and W. H. Smith of the D.S.I.R., Ditton Laboratory, East Malling, from material supplied by the N.A.A.S.

Vegetable Washing Practice as shown by Survey

The washing of vegetables is known to be practised in thirty-six counties of England and Wales, but the extent varies widely. In Bedfordshire and Middlesex, for instance, it is reported that 100 per cent of vegetable growers wash some vegetables ; in Cornwall less than 1 per cent. In the Eastern Counties, where there is much root washing, a large proportion of the growers who wash vegetables use machines. In Norfolk 90 per cent of vegetable washing is done by machine, and in Suffolk it is reported that all carrot washing is by machine.

Probably the crops washed most extensively are maincrop carrots and bunched salad vegetables. Most growers wash other vegetables only when they are unusually dirty, as for instance when lettuces become splashed with mud during heavy rain or after overhead irrigation.

Of the vegetables washed mechanically, maincrop carrots take first place ; celery, leeks, salads and bunched vegetables are much less often washed by machine. Beans, bunched beets, cauliflowers, celeriac, mint, parsley, rhubarb, and vegetable marrow were not reported as being washed mechanically.

As might be expected, of the soil types farmed by the growers from whom details were received, the majority were light loams or sands ; only eight out of seventy-one farmed heavy loams. This is perhaps fortunate, since the difficulty of washing must increase with increasing heaviness of the soil.

The method of washing most frequently used is to lay the vegetables on a concrete floor and spray them with a hose. Washing is frequently carried out by rinsing in a tank, sometimes accompanied by the use of a soft brush to remove adhering soil. Frequently tank-washing and hosing are combined. One grower was reported as washing vegetables by laying them in a stream.

Out of forty-six growers reported using machines, twenty-six used types in commercial production and sixteen used machines of their own design or construction.

The following types of machine were described :

Type A employs an inclined rotary drum partly submerged in a tank of water. On leaving the drum the vegetables pass on to an inclined conveyor, on which they are sprayed with clean water and passed to the packer.

Type B employs a horizontal rotary drum through which the vegetables pass and are washed by water from taps. (See Fig. 1, p. iv of the art inset.)

Type C employs a cradle with a slatted bottom. The vegetables are rocked violently and water is thrown over them either from buckets or with a hose. This method is suitable only for carrots.

Type D employs a narrow horizontal tunnel full of water through which the roots are made to pass. The roof is hung with 2-inch thick coconut matting which scrubs the vegetables clean.

Type E employs a narrow horizontal tunnel through which the vegetables pass on a continuous conveyor belt while they are sprayed by jets of water.

The home-made or home-designed types employ the same principles as the above commercial types. Frequent use is made of a horizontal circular conveyor or turntable, the vegetables being sprayed from above and below.

Among the growers for whom returns were received, Type B was by far the most popular.

More than 50 per cent of the growers reported, used water from company's mains. Other sources of water were wells, river, stream, ditches, own bore, pond, spring and fen dyke.

In a large number of instances growers stated that they had not received complaints from their salesmen at the markets about the condition of washed produce. Generally, they qualified their observations by a remark that implied that they found the washing of certain vegetables an imposed duty, and the incentive to wash arose largely from a desire for better presentation and increased financial returns.

Additional comments suggest that the present methods of washing vegetables considerably decrease their keeping qualities, inasmuch as those concerned with the keeping of vegetables for a prolonged period insist that they should be unwashed.

The survey clearly indicates that owing to the high initial cost only growers with large acreages of vegetables are inclined to install mechanical washing equipment. The inadequacy of water supply in rural districts is another factor affecting the restricted use of mechanical washers.

Further Investigation Needed A second stage of investigation is now under way. This consists of an attempt to determine in what way the washing of vegetables affects their subsequent keeping quality. The method employed is to divide a field run of produce as it is delivered to the washing floor, so that a control sample unwashed can be consigned alongside the washed material and kept under observation through the subsequent stages of marketing and distribution. These experiments should make a valuable contribution to the body of information needed by the designers of vegetable washing machines.

The author of this paper, which is published with the approval of the Departments and Institutions involved, is the Convenor and Chairman of the Working Party on Vegetable Washing. The other members of the Working Party are Mr. A. G. M. Bean (N.I.A.E.), Dr. J. C. Fidler (D.S.I.R.), Mr. J. F. Goaman (M.A.F.), Mr. N. E. Holmes (M.O.F.), Mr. G. C. Maltby (M.O.F.), Mr. A. P. Winsor (N.A.A.S.).

GLASSHOUSES
(FINAL RESULTS) 1951–52

GLASSHOUSES (*a*)

	Square Feet (thousand)		Equivalent Acreage (*b*)	
	1951	1952	1951	1952
TOTAL AREA OF GLASSHOUSES				
With heating apparatus	169,729	170,783	3,896	3,921
Without heating apparatus	27,803	27,947	638	641
TOTAL	**197,532**	**198,730**	**4,534**	**4,562**
CROPS IN GLASSHOUSES AT JANUARY 15				
Lettuce	21,409	22,575	491	518
French beans	258	268	6	6
Mushrooms	1,588	1,670	36	38
Other vegetables and herbs	3,136	3,677	72	85
Tomato and cucumber seedlings	12,856	(*c*)	295	(*c*)
Carnations	5,911	6,874	136	158
Roses	3,127	3,829	72	88
Orchids	421	428	10	10
All other flower and foliage crops	23,476	26,800	539	615
All other crops not specified above	6,279	19,309(*c*)	144	443(*c*)
Remaining glasshouse area, being the area unused at January 15, or used for other purposes not shown above	119,071	113,300	2,733	2,601
TOTAL	**197,532**	**198,730**	**4,534**	**4,562**

	Area of Chrysanthemums at December 1, 1950		Area of Chrysanthemums Grown in Autumn and Winter 1951	
	Square feet (thousand)	Equivalent acreage (*b*)	Square feet (thousand)	Equivalent acreage (*b*)
Chrysanthemums In glasshouses	26,562	610	32,650	749

	Area completely cleared before January 15, 1952	
	Square feet (thousand)	Equivalent acreage (*b*)
Lettuces	4,144	95

(*a*) Holdings with less than 1,000 square feet of glass are not included in the above.

(*b*) Calculated to the nearest acre.

(*c*) Tomato and cucumber seedlings are now included under "All other crops not specified."

AGRICULTURAL STATISTICS: GLASSHOUSES

FRAMES, LIGHTS, BELLS AND CLOCHES (*a*)

	1952	
TOTAL NUMBER OF LIGHTS	1,283,000	
TOTAL NUMBER OF BELLS AND CLOCHES	1,706,000	
AREA OF CROPS EXPECTED TO BE CULTIVATED UNDER LIGHTS, BELLS AND CLOCHES IN THE SPRING OF 1952	Square Feet (thousand)	Equivalent Acreage (*b*)
Lettuce	11,274	259
Carrots	1,001	23
Cauliflowers	907	21
Radishes	586	13
Strawberries	1,208	28
Flowers and foliage crops	4,944	113
Other crops	4,926	113
TOTAL	24,846	570

(*a*) Holdings with less than 1,000 square feet of glass are not included in the above.

(*b*) Calculated to the nearest acre.

FARMING AFFAIRS

Dried Grass/Lucerne and the Dairy Cow It is estimated that we are now producing in this country over 200,000 tons of dried grass, lucerne and other green fodder crops a year. Properly made, at the right time, it is an important source of protein, and we should make the best possible use of it. High quality dried grass or lucerne is of concentrate value, but, of course, it is not such a concentrated food as a blend of oil cake and cereals, and therefore it is necessary to feed more of it per gallon than of a compound cake. When due allowance is made for the maintenance ration (which may account for half the bulk of a cow's daily food intake), it seems that normally no more than 12-15 lb. dried grass should be fed in addition. If such a quantity of dried grass is able to supply the needs for three gallons of milk, any additional production requirements would best be met from a more concentrated type of production ration. Dried grass (maintenance quality, i.e., below 13 per cent protein), could be used, with advantage, in place of hay in the rations of very high yielders, where it is usual to feed concentrates for all milk being produced.

For practical feeding purposes, the quality of dried grass and lucerne can be assessed in steps at intervals of 2 per cent crude protein, assuming that, as fed, the material contains 10 per cent moisture (picked up from the atmosphere after drying).

With an adequate maintenance ration, such as 10 lb. average meadow hay and 50 lb. roots, the feeding of dried grass to dairy cows might be:

Feeding of Dried Grass

Crude Protein Content (10 per cent moisture basis) *per cent*	Quantity to be fed for each gallon of average milk* produced	
	Dried Grass (*lb.*)	*Oats* (*lb.*)
21.0 and over	2	2½
19.0 to 20.9	2½	2
17.0 to 18.9	5	—
15.0 to 16.9	5½	—
13.0 to 14.9	Either (a) 5 lb. dried grass *plus* ½ lb. of high protein cake	
	or (b) 4 lb. dried grass *plus* 1 lb. medium protein cake or beans	

With the above mixtures it is recommended that 2½ per cent dairy minerals be added to ensure an adequate mineral intake.

Dried lucerne is richer than dried grass in digestible protein in relation to its energy value, and for that reason it usually needs balancing with a cereal food. Here the feeding guide for dairy cows is:

Feeding of Dried Lucerne

Crude Protein Content (10 per cent moisture basis) *per cent*	Quantity to be fed for each gallon of average milk* produced	
	Dried Lucerne (*lb.*)	*Oats* (*lb.*)
Over 23.0	2½	2½
21.0 to 22.9	2½	2½
19.0 to 20.9	3½	1½
17.0 to 18.9	3½	1½
15.0 to 16.9	5	¾
13.0 to 14.9	6½	—

Lucerne is rich in lime, therefore it is advisable to supplement the above feed with 2 per cent of a high-phosphorus type of mineral.

Farming Cameo: 21. Tavistock, Devon The Tavistock district of Devon lies immediately west of Dartmoor, and extends from the Moor to the River Tamar, which forms a natural boundary between Devon and Cornwall. The district includes the greater part of Dartmoor, which, as one would expect, is a hill farming area. The remainder of the district consists of a high plateau or table-land, intersected by numerous valleys, which descends gradually to the Tamar Valley.

Rainfall is relatively high, ranging from about 100 inches per year at Princetown, in Dartmoor, to 35-40 inches at lower altitudes. Arable farming is therefore restricted, and the district is predominantly grassland. With the low proportion of tillage on the farms and the steep contour of much of the land, the amount of rotational grass is also relatively small; most of the grass consists of old permanent pasture.

Some of the best permanent pastures in Devon are to be found in this district, in the parishes of Lamerton and Milton Abbot. Indigenous ryegrass and white clover predominate, and they can fatten a bullock to the acre, even at altitudes of 600-800 feet. It has to be admitted, however, that much of the permanent pasture could be improved by liming and the judicious use of phosphates. Many of the pastures contain too much bent, which tends to thrive under the acid soil conditions and grazing management which

* For Channel Island and South Devon Breeds, these quantities should be increased by one-fifth to allow for richer milk.

inclines towards over-stocking in spring and under-stocking in late summer and autumn.

In an average year the grass season is a long one. Stock can go out to a good bite of grass at the end of March, and farmers on the better soils usually look for grass up to Christmas.

Most of the farms on the fringe of Dartmoor have grazing rights on the Moor; the number of stock which can be put out to graze is related to the number which the farm could be expected to carry over the winter.

Stock-rearing is traditional in the district, and on the average farm (usually 50-100 acres) the only milk sold is that left over after the calf-rearing requirements have been met: and the calves are never stinted as far as milk is concerned.

The dual-purpose South Devons predominate, although Galloways, and to a greater extent the Highland breeds, are accepted as being best suited to the scanty living offered on Dartmoor in competition with the native breed of ponies. Breeds of sheep are, like the sheep themselves, fairly numerous. On the lower ground, the Dartmoor is the most popular breed, while out on Dartmoor itself the Scotch Blackface is well represented; Exmoor and, to a lesser degree, Cheviot are also to be found.

Of the crops grown in the district, cereals are mostly utilized for the feeding of stock, and oats and dredge corn take up the better part of the acreage. Potatoes yield well when planted early, and an early bulking variety such as Arran Banner is usually grown. Potato Blight appears at the end of July or the beginning of August in most years, usually coinciding with the sea fogs from the Atlantic, so that crop growth is often prematurely stopped. Good stocks of seed potatoes could be grown in the district, but so far few farmers have taken advantage of the very favourable conditions for their production.

Kale is a popular crop, and while much of it is cut and carted to the stock, grazing it is on the increase since it fills in the short gap in what is normally a long, grass season.

The work of a District Advisory Officer in this corner of Devon is obviously concerned with the improvement of grassland and methods of conserving grass which are best suited to the locality. Haymaking where the rainfall is high is obviously a gamble, and silage-making has been encouraged in every way possible. From a nucleus of a few pioneers, one farmer out of every five is now making it – a heartening development in a district where old customs are usually regarded as best.

Launcelot Rennie,
District Advisory Officer

Sowing Rates of Cereals How much cereal seed is likely to give the best return per acre? Writing in the current issue of the *Empire Journal of Experimental Agriculture**, Dr. D. A. Boyd of Rothamsted suggests that sowing rates in some parts of Britain for winter wheat, spring barley and oats are generally excessive. He has reached this conclusion after a careful examination of the results of the many experiments on the effect of seed rate on yields which have been carried out in the British Isles during this century. His summary covers 147 trials and includes some comparable data from Scandinavian countries.

* The Effect of Seed-Rate on Yields of Cereal. D. A. Boyd. *Emp. J. exp. Agric.*, 1952, 20, 115-122.

It is known that in many districts seed rates are of the order of 3 bushels per acre for wheat and barley, and, for oats in the wetter districts, some 6-8 bushels. Dr. Boyd's data suggest that 2 bushels per acre for wheat and barley and 4-5 bushels for oats are nearer the optimum seed rates.

Naturally, the farmer must continue to use his judgment in the light of his own individual circumstances and the particular field he is sowing, reducing the rate for early sown crops and in conditions of high fertility or where Take-all or Eyespot is expected, and increasing the rate where soil pests are known to be present and for late sowings and rough tilths. These apart, it seems that many farmers could substantially reduce the amount of seed sown without loss in yield.

Other factors, of course, have their influence—varieties, soil, manuring, and sowing dates, and further experimentation is needed to show just what their effect on sowing rates may be.

Water Supplies on the Farm In the successful operation of a modern farming enterprise an ample and well-sited supply of pure piped water is essential. Its influence is felt in every direction; on the newly-developed hill and marginal land, in milk production, for irrigation on the market garden and the fruit farm, and, not least, for adequate stock watering. In all these respects, water is virtually synonymous with maximum productivity.

In the past the requirements of the farm were often met from a nearby well, pond or ditch, even though it may frequently have been badly polluted. The more fortunate made use of a spring, and if the flow was unreliable in dry weather the Clerk of the Weather was suitably apostrophized.

But changing methods have brought an ever-increasing demand for water and so required us to pay more attention to natural water supplies. Experts are being called in to analyse the water in the spring, to calculate the output and advise on how best it may be harnessed, collected and protected from pollution.

To make full use of available supplies, some kind of pumping and storage installation is necessary. Two methods can be used: the water may be stored at a high level on the farm for subsequent distribution by gravity, or it may be pumped into a pressure tank and, by use of the air pressure in the tank, forced automatically to all parts of the farm. Both systems have their protagonists and both have their particular advantages. The size of the installation chosen will, of course, depend upon the output from the selected source and the quantity and pressure required. The latter is likely to vary considerably between farms. For instance, to put 1 inch of water per day on 1 acre will involve 24,000 gallons, a cow in milk will require 15 gallons a day, a working horse 10 gallons, while an ordinary hose for cleaning down will use 2-5 gallons per minute.

Perhaps the greatest immediate advantage of an adequate, piped water supply is the saving in labour which it brings. Water-carrying becomes a thing of the past, hoses replace buckets, cattle no longer have to be driven to water. Even if this saves on 2 man-hours per day, that is a saving to the farmer of about 30s. per week.

A new booklet, issued by the British Electrical Development Association is a useful guide to this subject. It is priced 1s. 6d. (including postage) and is obtainable from the Association at 2 Savoy Hill, London, W.C.2.

BOOK REVIEWS

Untaken Harvest. GEORGE ORDISH. Constable. 15s.

When the first sower sowed the first seed he (or more probably she) could not have foreseen the centuries-long chain of reaction which that simple and original act of husbandry would set off. So long as populations remained low, losses to man's competitors could be endured in a sense of fatality, but as peoples multiplied so the seriousness of a meagre harvest increased. The world today, with its population of some 2,450 millions increasing at the phenomenal rate of fifty thousand a day, faces a food problem of unparalleled gravity. There are no more vast fertile areas or undiscovered continents to be explored and exploited ; we know our geographical and physical limitations, and any increase in food production must therefore be intensive.

It is against this background that Mr. Ordish, agricultural economist to Plant Protection, Ltd., examines the problem of the " untaken harvest "—that aggregation of loss of food crops all over the world due to the depredation of insect pests and diseases and the fierce competition that springs from weed infestation. In Britain alone, he estimates (on 1947 data) a loss of 1.9 million acres which virtually produce no crops—equivalent to £78 million; and these figures do not take into account every crop nor losses in storage. " We can express the loss very graphically," he says, " by saying that in effect over thirty-three thousand farms produce no crops in the United Kingdom, and that the labour of more than fifty-one thousand skilled farm-workers is wasted on account of the ravages of pests." The advance of knowledge in the effective control of all pests and diseases of any economic significance has been dramatic since the first determined steps were taken about 1860. Insecticides, fungicides, weed-killers, biological control—all are playing an increasingly active part, but Mr. Ordish is rightly mindful of the fact that crop protection means higher costs of production to the farmer, for materials, equipment and labour. Inevitably and unavoidably this means higher prices to the consumer, but it is a legitimate insurance charge against hunger. The view that there is any financial gain to the farmer in some degree of pest or disease incidence to prevent surplus, the author disposes of with a logic that brooks no argument.

The sociological effects of crop pests and diseases are no less marked than the economic, from which, of course, they mainly derive. Apart from the testament of history, we can see in our own day how profoundly the development of the biological sciences has been, and is being, influenced by control considerations ; how the need to grow certain crops in healthy areas to escape disease reacts on local communities ; how great are the commercial and educational interests focussed on the problems which they present. Not least is the emphasis on the co-operation between the government, commerce and the farming industry in matters of crop protection. The need, the problem, the research, the answer—these are the co-ordinate links in the chain ; only the grower can forge the final one—application.

Mr. Ordish looks upon (to adapt Shakespeare) " those acres in England that do no work today". He sees a potential of yield lost to diseases, pests and weeds, and rightly urges " a better co-ordination of research, a better dispersal of existing knowledge, and a better use of sprays, resistant varieties, parasites and all the modern means of protection " that could arise from a closer economic study of the problem.

Without question, this book is among the most important of contemporary agricultural literature, as establishing a field of inquiry and pursuit to obtain more food to the acre and less hunger in the world.

S.R.O'H.

Hosier's Farming System. A. J. HOSIER and F. H. HOSIER. Crosby Lockwood. 21s.

Covering the life history of A. J. Hosier from boyhood to date, this book is crammed with a tale of improvization, adaptation, initiative—in fact all that goes for successful private enterprise. Though the title promises a carefully thought out "plan" of management, and a complicated organization springs to mind when one thinks for a moment of the 11,000 acres involved, yet the authors are at pains to show throughout the book that no such "system" exists. Flexibility is the keyword, and scorn is poured mercilessly on all that is hidebound and traditional. Yet it is clear that a place is always reserved for what is best of the old order—the threshing machine and thatching both retain a place in the affections and the economic considerations of A. J. Hosier ; " the up-to-date farmer seems to be in danger of becoming concrete-minded metaphorically as well as literally " in a sentence shows that he is not prepared to accept all that is new without question.

There are nineteen chapters—including a summary—describing the between-war struggle (in which the well-known bail milking and poultry folding equipment were evolved), the alternate husbandry practised before Aberystwyth grasses and clovers were as well known as today, the outstanding achievements during the 1939-45 war, and the post-war period. The fact that the system was built up in a period of cheap imported food and cheap land and yet thrives in the total absence of both is sufficient tribute to its adaptability.

The final chapter describes in typically modest language the public work of the father—a man who shuns publicity, who has not refused to take a part in organizations, committees and associations when asked to do so and yet who has found them all too unwieldy for his originality of thought and action.

The chapters devoted to silage-making (in which stack silage is favoured), methods of cultivation, and grain handling are apt to invite the comment that these methods are all very well for an enterprise of this magnitude but not of much help to the small farmer, but let it always be remembered that A. J. Hosier was once small (he confesses that at one stage his capital was £200). No one need be discouraged, even today, with the smallness of their capital ; the will to work all hours, to seize difficulties as things to be overcome are qualities of infinitely more value than a handsome bank balance.

Not every invention was successful—there are even illustrations of some of the unsuccessful—others were superseded as times changed, many more have become the standard practice of farmers especially in the south. Few have been patented ; they were thought out primarily for the use of the inventor and if others wanted them nothing could be simpler than manufacturing them for sale !

Unstinting tribute is paid to the many workers who have contributed to the success of the enterprise ; their long years of service show that the system was not devoid of feeling or thought for the wellbeing of its operatives. Fairly early in the book it is stated that the underlying theme of the enterprise is the problem of production per man-hour. This has not led to the short-sighted policy of using mechanization as a means of sacking men but rather of increasing the output per man—this sort of labour utilization must mean greater output per acre—to the ultimate good of the nation.

" Our way is not every farmer's way, and our methods are not for everyone ; we have made a success of them, and venture to hope that our experience may be of some value to others." Thus a quotation from the penultimate chapter, which epitomizes the book.

D.R.B.

Introduction to Soil Science (2nd Edition). G. W. Leeper. Melbourne University Press. 21s.

There have appeared, during the last five years, a number of books on soil science and among them several text-books emanating from different parts of the Commonwealth. To readers in this country all such productions should be of interest as portraying the subject against a background of natural conditions, often markedly different from those which exist here.

We now have, in Mr. Leeper's book, one written in simple language by an Australian of the State of Victoria, primarily for the benefit of his own countrymen. His account is divided equally between soil in the field, soil physics, and soil chemistry and much can be said for their being in that order, but within these sections the order of development of his theme appears less satisfactory. Starting with the study of the soil profile, the book proceeds to soil surveying, the production of soil maps, and the agricultural utilization of different soils. The subject of soil classification is next dealt with, and finally the processes of soil formation. Much of the latter could usefully have preceded the earlier chapter.

Soil moisture properties are of vital importance to Australian farming, and Mr. Leeper has included very attractive chapters on this topic. The one introducing the section devoted to soil physics, by its content and composition, is less effective than it might be. An order which put the chapters on mechanical analysis and soil colloids first, and used them to explain soil structure, thence leading up to the account of moisture in soil, might have proved more helpful to the reader. In the section on soil chemistry the implications of the chapters on nitrogen, phosphorus, and the trace elements, against the Australian background, should interest English readers.

It is difficult to produce fully satisfactory photographs of soil profiles. Mr. Leeper has included some examples in his book but has not given his readers as good guidance in the most difficult individual as in the clearest. Plate X would have been better for a depth scale and indications of the limits of the horizons referred to ; the others are clear enough without.

H.H.N.

Lancashire (County Books Series). WALTER GREENWOOD. Robert Hale. 15s.

No better choice than Walter Greenwood could have been found to write the Lancashire County Book. His name will readily come to the minds of many readers as the author, among several novels and plays, of that study in penury, *Love on the Dole*. Lancashire born and bred, he can justly claim an intimate knowledge of the County of the Red Rose in all its varied facets. He has not been content to present an objective picture, but one rich in detail and having depth in everyday Lancastrian life. He writes of people, places and periods with a forthright Northern candour that is alternately stimulating and provocative to read. He knows the light and shade of life, alike in the smoke-canopied industrial towns and in the open countryside of the Fylde, dales and fells. Neither does he hesitate to reveal the sordid equally with the serene. Such honesty of writing makes compelling reading.

Mr. Greenwood has a marked admiration for Lancastrian townswomen, labouring, like Sisyphus, in the attempt to keep their homes free of the all-pervading soot and grime. " Such is their character and training that not only do they scour the inside of their homes but, once a week, they attack the pavements outside their homes. Of a Friday evening, when this part of the housework is generally done, you will see them, or you could do up to 1939, kneeling in the streets, bucket, floorcloth and coloured sandstone at their sides, sluicing the water over the flagstones then rubbing them with the coloured sandstone and washing it afterwards into an even patch of colour. Some even scrub the bricks around the front door. . . . Nothing pleases her more than to put on to the table 'when they all come home from work' a delicious hotpot or a potato pie with a thick crust browned to a turn. Give her a couple of pounds of thick seam tripe, a few onions and a cow heel and she will set in front of you a dish fit for a king. One thing you will rarely see her do : that is, throw anything away. Bits of string go into the string-bag ; ends of tape, brown paper, newspaper, etc., all will be saved, and, if she is chided for this habit by the family, she will answer : ' It'll come in for something useful, don't fret.' It usually does : she sees to that."

Much of this book is eminently quotable, not least the author's ethical commentaries on the social and economic history of the county since the Industrial Revolution. There is anecdote and humour, and, above all, the common touch. In short, Mr. Greenwood has done a " gradely job".

S.R.O'H.

The Cyst-Forming Species of Heterodera. MARY T. FRANKLIN. Commonwealth Agricultural Bureaux. 18s. 6d.

This is a book written by a specialist for specialists. Its authenticity is immediately established because it is written by a member of the Nematology Department of Rothamsted where, under the guidance of Dr. Goodey, Dr. Franklin has for a number of years specialized in the study of plant parasitic nematodes of the genus *Heterodera*. Now she has very rightly decided that the time is ripe to share with others her unsurpassed knowledge of this very important group of plant pests.

The genus *Heterodera* includes *Heterodera schachtii* Schmidt, the Beet eelworm ; *H. major* (O. Schmidt), the Cereal Root eelworm ; *H. göttingiana* Liebscher, the Pea Root eelworm ; *H. cruciferae* Franklin, the Cabbage Root eelworm ; *H. humuli* Filipjev, the Hop Root eelworm ; and *H. rostochiensis* Wollenweber, the Potato Root eelworm. Each of these is fully described as well as one or two lesser known eelworms of this genus. The Root Knot eelworm, *H. marioni*, is not dealt with because it does not form cysts.

Although the book is written for specialists, it contains much of interest to the general agriculturist. One of the most important species of economic importance, *H. schachtii* the Beet eelworm, was first found infesting roots of sugar beet by Schacht in Germany as long ago as 1859. It subsequently became a very serious pest on the Continent, and Dr. Franklin says of it : " Although for over seventy years attempts have been made to eradicate *H. schachtii* from the soil of fields required for the cultivation of sugar-beet or mangolds, no practicable means of doing so have yet been developed". In this country, fortunately, the spread of this pest has been very greatly slowed down by the introduction of an Order. We have not been so lucky with the Potato Root eelworm ; Dr. Franklin deals objectively and sincerely with all the methods of control tried against this pest but, as with Beet eelworm, adequate rotation is still the only economic method of controlling it on maincrop potatoes in the field.

Until recently, nematology has been the Cinderella of the agricultural sciences and, although for some time the writing has been on the wall, only a few have seen it and realized the increasing threat to our crops by plant parasitic nematodes. Dr. Franklin lists 646 references ; over 350 of these papers have appeared in the last twenty years, so it would seem that means of support for research on nematodes are now being granted in many countries.

Although the author is obviously not to blame, it is surprising to see that the preface to this book was written in 1949 and yet only towards the end of 1951 does the book appear. The result is that although all the work done on the genus *Heterodera* up to 1949 has been most faithfully recorded there are no references to a number of important papers which have since appeared. A work of this nature must necessarily have a restricted sale, but in the scientific world it is the kind of book that marks an epoch in research on an important pest, and prompt publication is very important. The book has been very well printed and presented but it should have appeared two years earlier.

I.T.

Devon Farming : A First Study by the Devon Agriculture Study Group. Devon County Council. 3s.

This booklet breaks entirely new ground and should be of great interest not only to people connected with the County of Devon but also to others throughout the country who are concerned with the study of agricultural developments.

It is refreshing to note that a group representing the various aspects of farming in the county has been able to find the time to present in such a clear manner information which would otherwise be allowed to remain dormant in files. The maps showing the disposition of crops, grass and livestock convey a picture of the make-up of the farming in Devon in a way impossible to achieve by tables of statistics. The maps relating to the breeds of cattle, sheep and pigs are unique and should be studied with care, since they display data which has never been available in any form before.

The three articles included in the booklet provide a useful background to the maps, but there tends to be some repetition among them, such as frequent stress on the importance of grassland. This might have been avoided and so left space for more information on the physical background, which has been unduly compressed.

It is obvious that much work remains to be done on this study, and the first report is so promising that it is hoped that further, companion publications will be forthcoming.

P.J.M.

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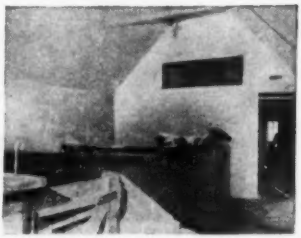

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10th March, 1952.

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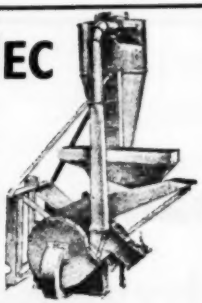

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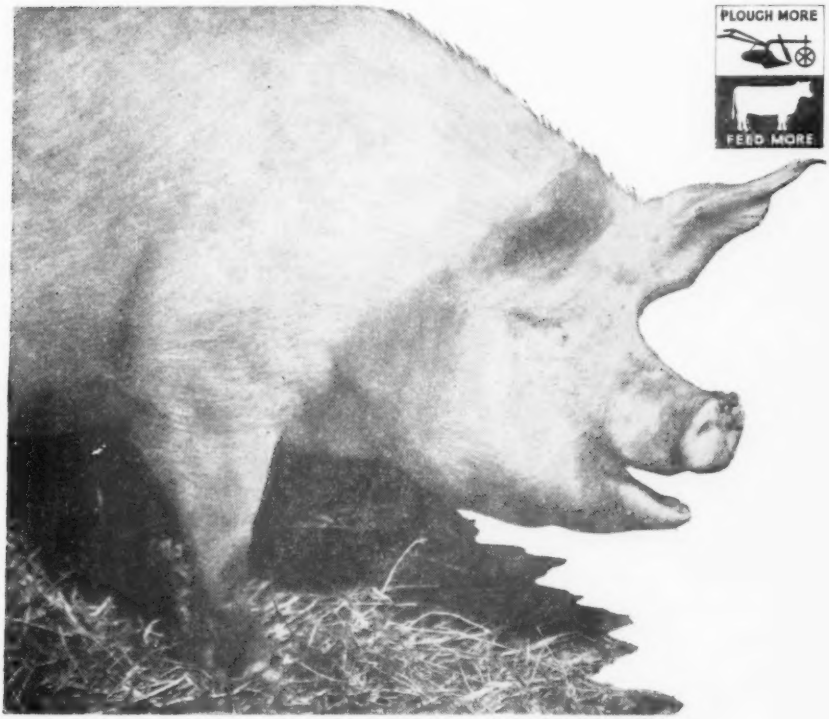

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HOW FISONS TRIPLE SUPERPHOSPHATE REDUCES LABOUR COSTS

Fisons Triple Superphosphate can cut your fertilizer labour costs by more than half. Your drills will cover a far greater area between each refilling when you use Triple Superphosphate. You will have far fewer sacks to move between barn and field. And, of course, Fisons Triple Superphosphate takes up much less of your valuable storage space than ordinary superphosphate does.

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Fisons Triple Superphosphate contains 47% water-soluble P_2O_5 (ordinary superphosphate, of course, has a P_2O_5 content of only 18%). In use 1 cwt. of Triple Superphosphate is the equivalent of 2½ cwt. of ordinary superphosphate. It is, therefore, the most economical form of soluble phosphatic fertilizer you can buy.

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Fisons Triple Superphosphate is granular and dust-free. It is free-flowing and stores well without caking. It is quick-acting.

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There are no lavish margins for farming profits today. Only by ensuring full crops can a farmer be sure of safe profit per acre. Fisons Fertilizers are the best investment.

31 & 33

Two important Triple Superphosphate Compounds

At the head of the Fisons range of compounds for 1952/3 are two concentrated compounds, No. 31 and No. 33. Both contain triple superphosphate. The analyses are given below and you will see that in both compounds nearly all the phosphate is soluble. No. 31 is high in potash, No. 33 is an N.P. Compound. They are both granular compounds and they are suitable for combine drilling.

More concentrated

These compounds have virtually the same plant food ratios as National compounds No. 1 and No. 3, but in a more concentrated form. By using Fisons No. 31 and No. 33 your labour costs are reduced — fewer sacks to move — less storage space required.

8 cwts. of Fisons No. 31 are equivalent to 10 cwts. No. 1 compound.

4 cwts. of Fisons No. 33 are equivalent to 6 cwts. of No. 3 compound.

Analyses

	Nitrogen N %	Phosphoric Acid Soluble P_2O_5 %	Phosphoric Acid Insoluble P_2O_5 %	Potash K_2O %
No. 31	9	8.25	0.75	15
No. 33	9	17	1	—

You can use Fisons No. 31 for:

Early and Main Crop Potatoes
Mangolds
Carrots and Parsnips
Kale and Cabbage
Flax and Linseed
Hops
Brussels Sprouts
Broccoli
Sugar Beet
Fodder Beet
Spring Corn (potash deficient soil)
Grassland:
Grazing (light land)
Early bite
Hay
Silage

and Fisons No. 33 for:

Swedes and Turnips
Kale and Cabbage (heavy land and with farmyard manure)
Spring Corn (phosphate deficient soil)
Rape
Grassland
Grazing (heavy land)

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